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Mining, Geological and Metallurgical Institute of India

TRANSACTIONS

of the

MINING and GEOLOGICAL INSTITUTE

of

INDIA

VOL. I.—3

EDITED BY

E. H. ROBERTON.

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The Mining and Geological ~~Society~~ Institute of India.

Officers for 1906.

Patron.

His Excellency the Viceroy and Governor-General of India.

President.

Mr. T. H. Holland, F.R.S.

Vice-Presidents.

Mr. William Miller.

Mr. Thos. Richards.

Council.

Mr. E. C. Agabeg.
,, F. J. Agabeg.
,, R. G. M. Bathgate.
,, R. J. Browne.
,, G. M. Darby.
,, James Grundy.
,, S. Heslop.
Mr. H. H. McLeod.
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,, J. J. Turnbull.
,, H. C. Veasey.

Mr. Thos. H. Ward.

Hon. Treasurer.

Mr. R. P. Ashton.

Hon. Secretary.

Mr. W. H. Pickering.

Hon. Editor of "Transactions."

Mr. E. H. Roberton.

LIST OF HONORARY MEMBERS.

NAME.	ADDRESS.
His Excellency the Viceroy and Governor-General of India ...	Calcutta and Simla.
The Hon'ble Mr. J. P. Hewett, Hon. Mem., Dept. of Commerce and Industry ...	Ditto.
Sir Andrew Fraser, the Lieutenant-Governor of Bengal ...	Calcutta and Darjeeling.
E. H. Walsh, Esq., I.C.S., Commissioner of Burdwan and Chairman of the Bengal Mining Board ...	Chinsura.

LIST OF MEMBERS.

NAME.	ADDRESS.
Adams, G. F. ..	Kusunda, Manbhum.
Adamson, Thomas ...	Giridih, E.I.R.
Agabeg, A. A. .	Jogta, Sijua, E.I.R.
* „ E. C.	Gaurandi, Panuria P.O., *via* Sitarampur, E.I.R.
* „ F. J.... ..	Barachuck House, Sitarampur, E.I.R.
Ambler, C. T. ..	c/o Messrs. Ambler & Co., Stone and Slate Works, Dharhara, E.I.R.
Armstrong, C. H. A.	Charanpur, Asansol, E.I.R.
Ashcroft, P. H.	The Bengal Coal Co., Raniganj Colliery, Raniganj, E.I.R.
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„ R. F.	East Kurkend Colliery, Kusunda, E.I.R.
„ W. ...	Joba Colliery, Kalipahari, E.I.R.
Bapty, G. F. W.	Asansol, E.I.R.
Barnard, Robert	Raniganj, E.I.R.
Barnett, E. L.	Panchgachia Colliery, Sitarampur, E.I.R.
Barrowman, R.	Jamuria Colliery, Nundi, Raniganj, E.I.R.
*Bathgate, R. G. M.	Kendwadih, Kusunda, E.I.R.
Bell, Reginald	Deshargarh, *via* Barakar, E.I.R.
Belletti, H. J. L. .	c/o Messrs. King Hamilton & Co., Koila Ghat Street, Calcutta.
Bennertz, E. S. ..	Loyabad, Kusunda, E.I.R.

* Member of Council for 1906.

Name.	Address.
Bone, D.	Bengal-Nagpur Coal Co., Jharia, E.I.R.
Bose, P. N.	8/2, Loudon Street, Calcutta.
Bosworth-Smith, P.	Tank Mine, Oorgaum, Mysore.
Brown, John Coggin	27, Chowringhee, Calcutta.
*Browne, R. J.	Jharia, Manbhum.
Brühl, Paul	C.E. College, Sibpur.
Bull, H. M.	Rajhara, Palamau, E.I.R.
Caplen, T.	Chipurupalli, Vizagapatam, Madras.
Chambers, H.	Lodna, Jharia, E.I.R.
Clark, W. H.	108, Cantonment, Kamptee, Central Provinces.
Collins, Robert	Kabulayatkatti, Dharwar, Bombay.
Cork, F. C.	Ganzlatar Colliery, Katrasgarh.
Cotter, G. de P.	27, Chowringhee, Calcutta.
Crabb, G. H.	Sitarampur, E.I.R.
Creet, S. T.	Ghusick Colliery, Kalipahari, E.I.R.
,, A. T.	Kalipahari, E.I.R.
*Darby, G. M.	Standard Coal Co., Jharia, E.I.R.
Darü, N. D.	Geological Survey, Canada.
DeVine, J. N.	Damodapore, Nundi P.O., Raniganj, E.I.R.
Dickson, Chas. A.	Dixon-Irvin Mica Mining Syndicate, Koderma, Hazaribagh.
Ditmas, F. I. L.	Chhindwara, Central Provinces.
Dixon, Geo.	Palana, Bikanir, Rajputana.
Dutta, P. N.	27, Chowringhee, Calcutta.
Dutt, P. C.	Jubbulpur, Central Provinces.
Fermor, L. L.	27, Chowringhee, Calcutta.
Fleischer, Theo.	Katras, E.I.R.
Fleury, H. G.	Jealgora, Jharia, E.I.R.
Foster, F. B.	Kusunda, Manbhum.
,, W.	Sanctoria, Sitarampur, E.I.R.
George, E. R.	Kabulayatkatti, Dharwar, Bombay.
,, Glen	Egwah, Raniganj, E.I.R.

* Member of Council for 1906.

NAME.	ADDRESS.
Gibb, J. B.	Benali, Searsol P.O., Raniganj, E.I.R.
Gough, G. H. ...	Bank Simula Colliery, Charanpur, Asansol, E.I.R.
Graves, H. G. .	2, Bankshall Street, Calcutta.
Griffiths, W. T. ...	C.E. College, Sibpur.
*Grundy, James	Sitarampur, E.I.R.
Hallowes, K. A. K. .	27, Chowringhee, Calcutta.
Hannaford, W. V. ..	Asansol.
Harris, G. E. ...	Margherita, Upper Assam.
Hayden, H. H. ..	27, Chowringhee, Calcutta.
Heilgers, F. W. ...	c/o Messrs. F. W. Heilgers & Co., 136, Canning Street, Calcutta.
*Heslop, S.	Asansol, E.I.R.
Higby, A. H. ...	Sijua, Manbhum.
Hockly, W. A. ...	Bhaga Colliery, Jharia, E.I.R.
Hodgkinson, T. G.	Sijua, Manbhum.
Holland, T. H. (*Pres., 1906*)	27, Chowringhee, Calcutta.
Hope, E. L. ...	Abbottabad, Punjab.
Hulloch, W.	Kusunda, E.I.R.
Kean, J. S. ...	Raniganj Coal Association, Jharia, E.I.R.
Keelan, P. S. ...	Katras-Jharia Coal Co., Seebpore, Jamuria, E.I.R.
	Charanpur P.O., *via* Asansol, E.I.R.
Kelly, L. St. John ...	Jogta, Sijua, E.I.R.
Langford, D. B. .	Dharwar Gold Mines, Kabulyatkatti, Bombay.
Lathbury, G. C. ...	Giridih, E.I.R.
La Touche, T. D. ..	27, Chowringhee, Calcutta.
Lea, Charles ...	Chichooria Colliery, Asansol, E.I.R.
Leach, G. Catterall ..	Giridih, E.I.R.
Leslie, Hugh M.	The Kolar Gold Field Metallurgical Establishment, Marikuppam, Mysore.
McCale, C. H. ...	Damuda Coal Co., Sitarampur, E.I.R.

* Member of Council for 1906.

Name.	Address.
*McFarlane, W.	Kendwa House, Kutti, E.I.R.
Mackintosh, James	Salanpur Colliery, Sitarampur, E.I.R.
*McLeod, H. H.	5, Fairlie Place, Calcutta.
McNeill, H. C.	Ramtek, Central Provinces.
Martin, H. C. ..	Toposi Colliery, Chaukidanga P.O., Raniganj, E.I.R.
Mervyn-Smith, A.	5, Cunningham Road, Bangalore.
Middlemiss, C. S.	27, Chowringhee, Calcutta.
Millar, J. A. ...	Chaukidanga P.O., Raniganj, E.I.R.
Miller, F.	East Indian Coal Co., Jharia, E.I.R.
,, George	Jharia, E.I.R.
,, N. ...	Standard Coal Co., Jharia, E.I.R.
,, W. (*Vice-Pres., 1906*)	Deshargarh, Sitarampur, E.I.R.
Mitchell, Robert	Nundi P.O., *via* Raniganj, E.I.R.
,, W. O.	Aldih Coal Co., Sitarampur, E.I.R.
Morris, Randolph H.	Chamarajnagar P.O., Mysore.
Mort, Arthur ...	Khost, N.-W.R., Baluchistan. [E.I.R.
Nairne, C. ...	Sarbori, Deshargarh P.O., *via* Barakar,
Nierses, J. W....	East Indian Coal Co., Kusunda, E.I.R.
Nixon, G. T. ...	Akyab Municipality, Akyab, Burma.
Owen, F.	Deshargarh, *via* Sitarampur, E.I.R.
Page, Hastings M.	Government College of Science, Poona, Bombay.
Pascoe, E. H. ...	27, Chowringhee, Calcutta.
Patel, Khan Bahadur, B.D.	Quetta, Baluchistan.
Patterson, E. M.	Charanpur, Asansol, E.I.R.
Phillipps, C. L.	Kusunda, Manbhum.
Pickering, W. H. (*Hon. Sec., 1906.*)	6, Dacre's Lane, Calcutta.
Pilgrim, Guy E. ..	27, Chowringhee, Calcutta.
Piggford, T. C.	Laikdih Colliery, Barakar, E.I.R.
Rees, W. J.	Bengal Coal Co., Giridih.
*Richards, C. H.	The Crotons, Coromandel P.O., South India.

* Member of Council for 1906.

NAME.	ADDRESS.
Richards, Thomas (*Vice-Pres., 1906.*)	Nandydroog Mine, Oorgaum Mysore.
Roberton, E. H. (*Hon. Ed., Trans., 1906.*)	C.E. College, Sibpur.
Rose, Arthur T.	Bengal Coal Co., Raniganj, E.I.R.
Russell, A. ...	Joyramdanga Colliery, Asansol, E.I.R.
Saise, Walter	Giridih, E.I.R.
Sam, A. V. ...	Sijua, E.I.R.
Sanders, A. A.	Kamptee, Central Provinces.
Savi, J. A. ..	Jealgora, Jharia, E.I.R.
Scott, G. F. ...	Raniganj, E.I.R.
,, Percival	Reliance Coal Co., Charanpur, Asansol, E.I.R.
Shearer, George ..	Manager, Barakar Brick, Tile, and Colliery Syndicate, Ld., Barakar, E.I.R.
Sheridan, A.	Sodepur, Sitarampur, E.I.R.
*Simpson, F. L. G. ..	Mohpani Mines, Central Provinces.
,, R. R. ..	6, Dacre's Lane, Calcutta.
Thaddeus, A. M. ...	Murulidi Colliery, Katras, E.I.R.
*Thomson, A. S.	Lodna, Jharia, E.I.R.
,, D.	Dandot, Jhelum, Punjab.
Tipper, G. H. ...	27, Chowringhee, Calcutta.
*Turnbull, J. J. ..	Jealgora, Jharia, E.I.R.
*Veasey, H. C.	Sijua, Manbhum.
Vickers, P. G....	Bhalgora Collieries, Jharia, E.I.R.
Walker, Harold ..	27, Chowringhee, Calcutta.
Ward, A. H.	Raniganj, E.I.R.
* ,, T. H.	Giridih, E.I.R.
Ware, S. D.	Gopalapuram, Kovur, Kristna, Madras.
*Watts, G. K.... ...	Nagpur, Central Provinces.
White, John	Jamadoba, Jharia, E.I.R.
Whyte, A.	Raniganj, E.I.R.
,, D. A.... ...	Central Kurkend Colliery, Kusunda, [E.I.R.

* Member of Council for 1906.

Name.	Address.
Whyte, E. A.	Bhuskajuri Collieries, Charanpur, Asansol, E.I.R.
Wills, Geo. St. John ..	Jamoni Coal Co., Ld., Madhuband Colliery, Katras, E.I.R.
Winch, H. J. ...	Meghnagar, B.B. & C.I. Ry., Central India.
Wordsworth, R.	Warora, Central Provinces.
Wright, C. M. P. ...	c/o Delhi and London Bank, Calcutta.
Yeoman, Thos. P. .	Warora, Central Provinces.

Associate Members.

Bennertz, A. E. ...	Kamptee, Central Provinces.
Cardoza, Chas. Henry ..	Calicut, Madras.
Edwards, E. W. M.	Karachi.
Gore-Langton, R. L. .	Vizagapatam, Madras.
Jones, A. A. Dennis .	C.E. College, Sibpur.
Maltby, F. B. ...	Churunpore, Asansol, E.I.R.

Extract from Minutes of Publication Committee, at a meeting held on March 5th, 1906.

Re Notes, Reviews, and Abstracts.

The following gentlemen shall be invited to be abstractors:—

(1) *Metalliferous mining generally*—L. Leigh Fermor.
(2) *Gold*—C. H. Richards.
(3) *Coal-mining*—Jas. Grundy, G. F. Adams, and W. T. Griffiths.
(4) *Geology*—H. H. Hayden and Guy E. Pilgrim.
(5) *Civil Engineering*—T. H. Ward.
(6) *Electricity*—Paul Brühl.
(7) *Medicine and Sanitation*—R. R. Simpson.

RULES

OF THE

MINING & GEOLOGICAL INSTITUTE OF INDIA.

NAME.

1. THE Institute shall be called the Mining and Geological Institute of India.

OBJECTS.

2. The objects of the Institute shall be the promotion of the study of all branches of mining methods and of mineral occurrences in India, with a view to disseminating the information obtained for facilitating the economic development of the mineral industries in the country.

CONSTITUTION.

3. The Institute shall consist of :—

(*a*) Ordinary Members,

(*b*) Associate Members,

(*c*) Associates, and

(*d*) Honorary Members, who shall include, *ex-officio*, the Lieutenant-Governor of Bengal, the Hon'ble Member of the Viceroy's Council for the Department of Commerce and Industry, and the Chairman of the Mining Board under the Indian Mines Act, 1901, in each Province, in addition to not more than ten others elected on account of their eminence in the Mining Industry, or branches of knowledge accessory to Mining.

ADMINISTRATION.

4. The administration of the affairs of the Institute shall be entrusted to a Council composed of the President, the two Vice-

Presidents, the Treasurer and the Secretary, together with as many Ordinary Members of Council as shall, with these officers, make a minimum total of fifteen or a maximum of twenty.

MEMBERSHIP AND ASSOCIATESHIP.

5. A candidate for membership shall make his application on Form A. The Council shall then decide whether he shall be proposed as an Ordinary or as an Associate Member. If it is decided that the candidate shall be proposed as an Associate Member, the fact shall be communicated to him by the Secretary before the voting papers are issued, unless he has previously intimated that he wishes to join as an Associate Member. A candidate for Associateship shall make application on Form B.

6. Voting for the admission of Members shall be entirely by post. The Secretary shall issue ballot papers to every Ordinary Member with the name and qualifications of every candidate for membership, and with a certificate of application endorsed by at least three Ordinary Members to whom the candidate is known personally. A month shall be given for the return of the voting papers. The votes shall be counted at a meeting of the Council of which the Secretary shall give at least seven days' notice to every Member of the Council of every meeting called to count the votes. At such a meeting two Members shall form a quorum.

7. No candidate shall be considered to be duly elected unless at least two-thirds of the votes recorded are in favour of his election.

NOTICE OF ELECTION.

8. The Secretary shall send a written announcement of his election to each candidate duly elected, and shall therewith send a copy of the Rules of the Institute for the time being in force.

ADMISSION FEES.

9. An admission fee of Rs. 30 shall be due on election from each Ordinary Member or Associate, and of Rs. 15 from each Associate Member elected. If this fee be not paid within three months after receipt by such person of notice of election, such election shall become null and void.

10. No person, although duly elected according to the foregoing Rules, shall be entitled to exercise the rights and privileges of Membership or Associateship, nor shall his name be entered on the list of Members or Associates, or published in the Proceedings, until he has paid his admission fee and subscription for the year then current, as provided by Rules 9 and 14.

11. The payment of such admission fee and first year's subscription shall be the commencement of effective Membership or Associateship, and shall be equivalent to the expression of a direct acquiescence in all the Rules and Regulations of the Institute then in force, and of an undertaking to be bound by them and by such as may thereafter be passed in accordance with the Rules hereinafter provided.

12. Rules 9, 10, 11, and 14 shall be printed or written on the notice of election sent by the Secretary to every Member or Associate newly elected.

Election of Honorary Members.

13. The names of those proposed for election as Honorary Members shall be first selected by the Council, and then communicated to the Ordinary Members, for voting in accordance with the system prescribed in Rule 6. With each name the Council shall submit a brief statement of the grounds on which the recommendation for Honorary Membership is considered proper or desirable. An Honorary Member shall not be considered to be duly elected unless two-thirds of the votes recorded are in favour of his election.

Subscriptions of Members.

14. The subscription of an Ordinary Member or an Associate shall be Rs. 30, and of an Associate Member Rs. 15 per annum, and shall be due on the 1st of January for the ensuing calendar year. Members elected between the 31st October and 31st December shall, however, be required to pay only one-half of one year's subscription for the calendar year then current.

15. No Ordinary Member, Associate Member, or Associate, whose subscription is in arrear for more than one year, shall enjoy the rights, or exercise the privileges of a Member or Associate, until he shall have paid all arrears due from him.

16. No admission fee or subscription shall be due from an Honorary Member.

COMPOUNDING FEE.

17. Any Ordinary Member, after he shall have paid his entrance fee, may compound for the payment of all future annual subscriptions by payment of a single sum of Rs. 200.

WITHDRAWAL FROM THE INSTITUTE.

18. Any Member or Associate may withdraw from the Institute by signifying his wish to do so, by letter addressed to the Secretary. A letter of withdrawal may be cancelled, at the request of the sender, within six months of its receipt by the Secretary, on payment of all sums for which the Member or Associate would have been liable, had his Membership or Associateship not been interrupted; and he shall, thereupon, recover all rights of Membership or Associateship, without the form of re-election.

19. Any Member or Associate member who shall cease to belong to the Institute either by voluntary withdrawal or by forfeiture of Membership or Associateship under Rule 31, shall continue liable to the payment of his annual subscription until he shall have discharged all sums, if any, due by him to the Institute, and shall have returned all books or other property, if any, borrowed by him of the Society, or shall have made full compensation for the same, if lost, injured, or not forthcoming.

RE-ELECTION OF MEMBERS RESIGNED.

20. Members or Associates who have withdrawn from the Institute shall be eligible for re-election; and, if re-elected, only half the usual admission fee shall be due from them.

NOTICE OF ARREARS OF SUBSCRIPTION.

21. If any Member's or Associate's subscription is not paid within three months from the date on which it becomes due, the Secretary shall cause a registered letter to be sent to him, directed to his last known address, informing him of the sums due by him, and that unless paid within nine months from the date of issue of such letter, his

Membership or Associateship will cease to be effective according to Rule 22. The Transactions of the Institute shall not be sent to any Member or Associate whose subscription is more than three months in arrear.

Removal of Defaulting Subscribers.

22. If a Member or Associate omits to pay the arrears due from him within one year from the date on which such arrears have been notified to him according to Rule 21, the Secretary shall send to him, in a registered cover by post, a notice similar to that provided in Form C, warning the Member or Associate that unless his subscription is paid within one year from the date on which the notice is despatched, his name will be recorded as a defaulter at the next following General Meeting. At this General Meeting, the Chairman shall declare the defaulting Member or Associate to be removed from the Institute for non-payment, and the fact shall be notified in the published Proceedings of the Institute.

23. A Member or Associate so removed by the operation of Rules 21 and 22 may be again made a Member or Associate, by a resolution of a General Meeting, on payment of all arrears and such further subscriptions as he would have been chargeable with, under these Rules, if his Membership or Associateship had continued; but he shall not be eligible for election under Rules 5 and 6.

Election of Officers and Council.

24. The election of Officers and other Members of Council shall take place at the Annual General Meeting of the Institute.

25. The Council shall prepare each year a list of the names of those Ordinary Members whom it recommends to be elected as President, Vice-Presidents, Treasurer, Secretary and other Members of Council for the ensuing year, and before the 15th December a copy of such lists shall be sent to each Ordinary Member.

26. The system of voting shall be similar to that adopted for the election of Ordinary Members, the forms for voting being so printed that a Member may strike out any name he pleases, and may substitute another in the place of any one on the list nominated by the Council. The forms returned, either in advance, or at the Annual

General Meeting, shall be examined by two scrutineers appointed by the Chairman of the Annual Meeting. If there be an equal number of votes in favour of two or more candidates, the scrutineers shall decide by lot which candidate shall have the preference.

27. No person shall hold the office of President for more than two consecutive years, but shall be eligible for re-election at and after the fifth Annual Meeting following that at which he vacated the office of President.

28. The three senior ordinary Members of Council, not being the Secretary or Treasurer, shall not be eligible for re-election until after the lapse of one year from the date of their retirement from the Council. For the first three years, seniority amongst the ordinary Members of Council shall be determined by lot.

29. In the event of a vacancy occurring between two Annual Meetings in the office of President, Vice-Presidents, Secretary, Treasurer, or Members of Council, it shall be competent for the remaining Members of the Council to fill up such vacancy, subject to the confirmation of the next Ordinary General Meeting. The Council may also, subject to the same confirmation, elect additional Members of Council as occasion may require within the sanctioned maximum.

30. If, for any reason, the Officers and Members of the Council should not be appointed for the ensuing year during the month of January, the Officers and Members of Council, elected during the previous year, shall continue to hold office until their successors shall be duly elected.

Deprivation of Membership for Misconduct.

31. If any Member of the Institute is guilty of unprofessional conduct, or of conduct calculated to bring discredit on the Institute, or shall wilfully disobey the Rules or Orders, or shall commit wilful breach of order at any of the General Meetings, or, having unwittingly committed, shall persist in any disobedience or breach of order, after being admonished by the President, he shall be liable to be removed from the Institute. Whenever there shall appear cause, as aforesaid, for the removal of a Member from the Institute, if a majority of the Council shall, after due deliberation, determine, by ballot, to propose to the Institute the removal of the said Member, the President shall,

at any Ordinary General Meeting, announce from the Chair such determination of the Council; and at the Meeting next after that at which the said announcement has been made, the proposition shall be submitted to ballot. If three-fourths of the Members present, and voting at such Ordinary General Meeting, vote for the removal of such Member, he shall be removed from the Institute.

32. Members removed under the operation of this section shall not be eligible for re-election until the expiration of one year from the date of such removal.

Powers of the Council.

33. The power and duties of the Council shall be as follows:—

(*a*) To prepare and submit to the Annual General Meeting a Report on the general concerns of the Institute. Such report shall set forth the income and expenditure for the calendar year. the balance in hand, the debts and assets, the estimated income and expenditure of the succeeding year, the prosperity, or otherwise, of the Institute, and the progress of the Library. The report shall also include an Abstract of the Proceedings of the Council during the year.

(*b*) In conformity with the provisions of the Registration Act, No. XXI of 1860 (Sections 9 and 10), the Council shall be empowered, subject to the sanction of an Ordinary General Meeting, to take legal proceedings under the Act for the recovery of any sums due by members who, after receiving due notice of their liabilities, shall refuse or fail to discharge them.

The Duties of the Secretary.

34. The duties of the Secretary shall be as follows:—

(*a*) To conduct the correspondence of the Institute and of the Council, and to sign all letters and papers emanating from the Institute.

(*b*) To attend the Meetings of the Institute and of the Council, to take minutes of the Proceedings of such Meetings during their progress; and, at the commencement

of every such Meeting, to read aloud the minutes of the previous meeting.

(*c*) To prepare for submission to the Ordinary Annual Meeting a list of Members, corrected to the close of the previous year.

(*d*) To enter, or cause to be entered, in the minute-books, all the Proceedings of the Institute and of the Council before the following Meeting, and to see that all letters, papers and documents of every kind connected with the business of the Institute are properly filed and preserved.

(*e*) To be *ex-officio* Member of all Committees appointed by the Council.

DUTIES OF THE TREASURER.

35. The Treasurer shall receive and hold for the use of the Institute all monies paid to the Institute; he shall disburse all sums due from the Society and shall keep exact accounts of all such receipts and payments. The Treasurer shall be *ex-officio* a Member of all Committees appointed by the Council.

MEETINGS OF THE INSTITUTE.

36. General Meetings of the Institute shall be of three kinds, *viz* :—

I.—Ordinary Meetings.
II.—Ordinary Annual Meetings.
III.—Extraordinary Meetings.

37. The following Rules shall be applicable to all General Meetings of the Institute :—

(*a*) Seven Ordinary Members shall constitute a *quorum*.

(*b*) The President or, in his absence, one of the Vice-Presidents shall take the Chair, or, in their absence, the Senior Member of the Council. If neither the President, nor one of the Vice-Presidents, nor a member of the Council be present on the expiration of fifteen minutes after the hour fixed for the Meeting, the Members present shall proceed to elect a Chairman.

(*c*) Notice of the time, date and place of every General Meeting shall be sent to every Member, Associate Member, or Associate at least a month before the date of the meeting.

(*d*) Notice of motion on any matter of importance shall be given at least one month before the date of the General Meeting at which the subject is to be disposed of, in order that Members who take an interest in the question may have an opportunity of informing themselves regarding it and expressing their assent or dissent; and no motion of which notice has not been given shall be carried at the Meeting at which it is proposed, if the President or Chairman of the Meeting rules that it should be postponed.

(*e*) All motions and amendments, except those emanating from the Council, shall require to be seconded; otherwise they cannot be put. Amendments must be in writing, unless excused by the Chairman. Not more than a single amendment to the original question shall be laid before the Meeting at one time. When any such amendment has been negatived, or has been allowed to take the place of the original motion, other amendments involving fresh points may be proposed.

(*f*) The usual method of voting shall be by show of hands; provided always that the votes on any particular subject may be taken by ballot, on a motion to that effect duly carried; and, in the cases especially provided for by these Rules, the votes shall be so taken.

(*g*) The Chairman's decision on the show of hands shall be final, unless a division be called for. It shall be competent to any Ordinary Member present to call for a division.

(*h*) The Chairman shall not vote with the rest of the Meeting; but when the votes for and against are equal, he shall have a casting vote.

38. The Ordinary Annual Meeting of the Institute shall be held

under the following Rules, and for the transaction of the following business:—

(*a*) The Meeting shall be held during the month of January in each year. If a *quorum* be not present the Meeting shall stand adjourned for one fortnight and so on until a *quorum* be present.

(*b*) Notice of the Meeting, of the hour at which it is to be held, and of the business to be transacted thereat, shall be given in two or more newspapers seven days at least previously.

(*c*) The business to be transacted at the Meeting shall be, first, to elect the Officers and other Members of the Council for the ensuing year as provided for in Rules 25 and 26; second, to hear the Annual Report prepared by the Council, in accordance with the provisions of Rule 33, Clause (*a*); third, to transact other business, of which notice has been given as provided in Clause (*b*).

39. The following Rules shall be applicable to Extraordinary General Meetings:—

(*a*) Such Meetings may be convened by a majority of the Council, and shall be convened by the President, when called on to do so by a requisition signed by not less than ten Ordinary Members, and stating the special business for which it is desirable that an Extraordinary Meeting should be convened.

(*b*) Notice of the day and hour of the Meeting, and of the special business to be transacted thereat, shall be given, one month previously, in three of the newspapers of the Presidency: provided that, if the business be very urgent, it shall be competent to the Council to substitute any earlier notice than that of one month; but no business of the nature specified in Rule 43, Clause (*c*), shall be deemed urgent, within the meaning of this Clause.

(*c*) No other business than that included in the notice shall be transacted at such Meeting, nor shall any stranger be permitted to be present thereat.

Meetings of the Committees appointed by the Council.

40. The Council may elect, from among their own body, Committees or Sections for the consideration of special subjects. They may also appoint Honorary or Asssociate Members, Associates, or Ordinary Members other than Members of Council, who are competent and well versed in the subjects to be referred to these Committees, to be Members of such Committees.

41. Committees shall cause minutes to be taken of their Proceedings. They shall report to the Council on all matters referred to them, producing such minutes, if called for.

42. Committees shall appoint their own Chairman and Secretary. Their duties, etc., in other respects may be defined by the Council, who may also dissolve such Committees when they think proper.

Votes of Ordinary Members.

43. The votes of Ordinary Members shall be taken and the procedure prescribed in Rule 44 observed, in any of the following cases :—

(*a*) When the Council, in their discretion, consider it for the interests of the Institute that an appeal should be made from the decision of an Ordinary Meeting to the whole body of Ordinary Members.

(*b*) When ten or more Ordinary Members sign a requisition, calling upon the President to make such an appeal.

(*c*) When any proposal is made respecting expenditure to a large amount, changes of organization, disposal of Securities forming part of the Permanent Reserve Fund, amendment or alteration of the Rules, or generally, when any question arises which, in the opinion of the Council, should be referred to the whole body of Ordinary Members.

44. Before circulating any question coming under Clause (*c*) of Rule 43, for the votes of the general body of members of the Institute, the Council shall cause to be sent to every Ordinary Member, at least seven days before the General Meeting at which such question is to be proposed, a printed circular in which shall

be set forth the nature of the proposal and the reasons for it, in order that it may be duly discussed at such General Meeting. A statement of any objections that may be raised at the Meeting against the proposal shall also be circulated with the voting papers.

Miscellaneous.

45. No person appointed to any office in the Institute to which a salary or any emolument is attached shall have the privilege of voting. If an Ordinary Member be appointed to any such office, he shall be incapable of voting at the Meetings of the Institute so long as he continues to hold it, but shall not be deprived of any of his other privileges of Membership.

46. There shall be kept such record of the Proceedings of the Institute, of its General Meetings and of the Meetings of Council, as shall be, from time to time, prescribed by the Council. All Ordinary Members shall be entitled to inspect such records.

47. When the introduction of any new Rule, or the alteration or repeal of any existing Rule, is recommended by the Council, or proposed by ten or more Ordinary Members, the Council shall cause to be sent to every Member of the Institute entitled to vote, a statement of the proposed changes and the reasons for them, with a view to the votes of the general body of Members being taken as directed in Rule 44. Provided always that no change in the Rules shall be valid unless a majority of three-fourths of the Members who have voted shall be in favour of the proposed changes. The rules relating to the election of Officers and Council shall not be operative until after the Inaugural General Meeting on 16th January, 1906.

48. No members or associates, other than Ordinary Members, shall be entitled to vote either for the election of new members and associates, or with regard to the revision of any of the Rules of the Institute.

Mining and Geological Institute of India.

BYE-LAWS RELATING TO PAPERS READ AT MEETINGS OF THE INSTITUTE.

(1) Any member wishing to read a paper before the Institute shall send a copy of it to the Honorary Secretary at least a month before the meeting at which he proposes to read it.

(2) If the paper offered for publication exceeds 3,000 words in length it shall be accompanied by an abstract not exceeding 500 words in length.

(3) The Council may refuse to allow a paper to be published in the Transactions without assigning any reason to the author.

(4) The Council retains the right to decide the form in which the papers shall be published in the Transactions, whether in full, in part, or in abstract, but when any abbreviation is made it shall be communicated to the author before the publication of the paper.

(5) No paper which has already been published elsewhere shall be published in the Transactions.

(6) The author of any paper published in the Transactions shall receive 30 copies of his paper in pamphlet form, free. He shall also be entitled, if he gives notice to the Honorary Secretary in writing before the meeting at which the paper is read, to further copies on paying the cost of printing.

(7) All papers accepted for publication shall be the property of the Institute.

The following bye-laws relate to the prize of Rs. 500, given by the Government of India, for the best paper published in the Transactions each year :—

(1) The prize will be given each year for the best paper reaching a prescribed standard and accepted for publication in the Transactions of the Institute.

(2) The decision as to which is the best paper will rest with a Judging Committee of five, appointed by the Council, who shall base their judgment upon both its scientific and practical value.

(3) In the case of two or more papers obtaining equal marks, the prize will be given to the paper of the greatest practical value.

(4) Two or more members may collaborate in writing a paper, and in that event, if the prize is awarded to the paper, it will be divided equally amongst the writers.

(5) No member of the Judging Committee shall be eligible to compete for the prize.

(6) The prize will not be awarded unless the Judging Committee are of opinion that a sufficiently high standard has been reached.

(7) The bye-laws of the Institute relating to papers appearing in the Transactions must be strictly observed.

Introduction

BY

Mr. W. H. Pickering.

THE inception of a scientific society is a comparatively rare event, and a short account of the preliminary steps which eventually led to the formation of the Mining and Geological Institute of India will be of more than passing interest, and may be useful for guidance in the event of similar ventures. India has produced many eminent civil engineers, and though their works live after them, and are the outward and visible sign of their true greatness, it will ever be a matter for regret that much of the information they collected and the conclusions they drew from their observations are mouldering in official files, and have never received the criticism and appreciation of their brother engineers. The same may be said of geologists, but with more reservation. Many distinguished names adorn the list of Indian geologists, and though much of their work is embodied in the "Records of the Geological Survey of India," and in their voluminous writings, many of their bye-products, which would have been saved by an Indian Institute, have been lost for ever. It is somewhat strange that the mining engineer should have arrived in India after the geologist and civil engineer, for he is generally a pioneer; but the fact remains that if we step backwards to the time of the great mutiny, the scientific-practical mining engineer was almost unknown in India. Mining, however, has made great progress during the present generation, and an attempt was made a few years ago to launch a Mining Institute, but it proved abortive. When the writer had been nearly a year in

India, and had gauged the trend of the mining thought, he came to the conclusion that he would not justify his position as head of the Mines Department, unless he could do something to place the profession of mining engineering on a higher level, and give it more importance in the eyes of the Indian public. Obviously, the best, and perhaps the only way of attaining this object, was to organise the mining engineers and form a Mining Institute. He resolved, come what might, to make the attempt at the first opportunity, and was encouraged and helped from the first by Mr. T. H. Holland, the Director of the Geological Survey of India. Geologists and mining engineers are brothers, and it was natural that they should unite. The psychological moment arrived somewhat unexpectedly. On the 10th November 1905, the prominent Bengal mining engineers had been invited by the writer to meet the Hon. Mr. J. P. Hewett, Member of the Viceroy's Council for the Department of Commerce and Industry, who contemplated a visit to the mining districts. At the last moment the tour was abandoned, but it was decided still to have the meeting and breakfast as arranged, and to make it an opportunity for discussing the question of the formation of an Institute. The meeting was attended by 38 gentlemen, and nearly every important colliery in Bengal was represented. Mr. R. Mitchell, as the oldest mining engineer present, was made chairman. A long and animated discussion followed, and, eventually, it was unanimously agreed that the establishment of an Institute to promote the cause of coal and metalliferous mining and geology and the allied sciences in India was desirable, and that a serious attempt should be made to form such a society. Mr T. H. Holland, F.R.S., Director of the Geological Survey of India, was nominated President, and a Provisional Committee was appointed with the writer as Honorary Secretary *pro-tem.* The first business was to give the

society a name, and after considerable discussion it was decided that it should be called "The Mining and Geological Institute of India." Circulars were issued to all well-known mining engineers and geologists in India, inviting them to join the Institute as original members. Some 150 invitations were issued and there were 131 acceptances. This was distinctly encouraging. The members were from the provinces of Bengal, Assam, Bombay, Madras, Baluchistan, Punjab, Central Provinces and the Nizam's Territory. Coal-mining engineers were the most numerous, but the engineers engaged in gold, manganese and mica-mining were well represented, and all the prominent Indian geologists joined. Thus, from the first, the Institute was broad based upon a wide constituency representative of Indian mining and geological interests. The rules were drafted by a small sub-committee, and finally the Provisional Committee made arrangements for the inaugural meeting. An invitation to visit Charanpur Colliery was received from Messrs. Apcar and Company through Mr. F. J. Agabeg, and Mr. Agabeg also, on behalf of the Chota Nagpur Mounted Rifles, offered the club house for the meeting. It was decided to take advantage of these kind offers and to have the inauguration on Tuesday, 16th January, 1906. His Honour Sir Andrew Fraser, Lieut.-Governor of Bengal, the Hon. Mr. J. P. Hewett, Member of the Viceroy's Council for the Department of Commerce and Industry, and Mr. E. H. Walsh, Commissioner of Burdwan and Chairman of the Bengal Mining Board, had been approached and had consented to be Honorary Members, and to attend the inauguration. They gave the Institute their most cordial support and approval, both officially and privately, and took great personal trouble in helping to establish it. Without their co-operation it could not have been such an assured success from the first. His Excellency the Viceroy and

Governor-General of India had also consented to support the movement by being Patron.

When sufficient time had elapsed to allow for replies to be received to the circulars, the Provisional Committee met at Kusunda on the 8th January 1906, or 8 days before the date fixed for the inauguration. The names of those who had accepted invitations to join as original members were carefully considered, and the following officers and members of council were nominated as proportionately representing all classes and interests :—

President, Mr. T. H. Holland; *Vice-Presidents*, Messrs. W. Miller and Thos. Richards; *Honorary Treasurer*, Mr. R. P. Ashton; *Honorary Secretary*, Mr. W. H. Pickering; *Council*, Messrs. E. C. Agabeg, F. J. Agabeg, R. J. Browne, R. G. M. Bathgate, G. M. Darby, Jas. Grundy, S. Heslop, H. H. McLeod, W. McFarlane, F. L. G. Simpson, A. S. Thomson, J. J. Turnbull, H. C. Veasey, C. H. Richards, and T. H. Ward.

All these gentlemen were asked to accept office if elected, and it was an encouraging and interesting fact that there was not a single refusal to serve.

Inaugural Meeting.

On the inaugural day, 16th January 1906, Mr. Hewett was prevented by illness from attending, but Sir Andrew Fraser, Mr. E. H. Walsh and 80 original members travelled to Charanpur Colliery by special train. After an inspection of the colliery, the members breakfasted together as guests of Messrs. Apcar and Company.

In the afternoon the inaugural meeting was held at the Chota Nagpur Mounted Rifles Club, Asansol, when there were present: Sir Andrew Fraser, Messrs. E. H. Walsh, T. H. Holland, W. H. Pickering, Jas. Grundy, G. F. Adams, Arthur Rose, T. C. Piggford, G. H. Crabb, T. H. Ward, H. G. Fluery, G. M. Darby, W. T. Griffiths, G. W. Bapty, W. Foster, R. J. Browne, J. A. Millar, E. S. Bennertz, Jas. Mackintosh, E. C. Agabeg, F. B. Foster, D. A. Whyte, A. A. Agabeg, W. McFarlane, R. P. Ashton, H. H. Hayden, P. S. Keelan, H. C. Veasey, J. J. Turnbull, A. S. Thomson, C. H. McCale, Paul Brühl, F. W. Heilgers, Percival Scott, H. H. McLeod, W. V. Hannaford, E. A. Whyte, Theo. Fleischer, S. Heslop, G. H. Gough, H. C. Martin, E. H. Roberton, A. Whyte, F. J. Agabeg, C. T. Ambler, Chas. A. Dickson, J. W. Nierses, W. O. Mitchell, L. L. Fermor, D. Bone, Robert Mitchell, Robert Barnard, Geo. Miller, John White, E. M. Barnett, C. H. Armstrong, Geo. Wills, W. Creet, J. S. Kean, Guy Pilgrim, H. M. Bull, A. M. Thaddeus, W. Miller, E. M. Patterson, Alex. H. Ward, F. Owen, W. A. Hockly, A. Sheridan, C. C. Augier, J. A. DeVine, R. G. M. Bathgate, Reginald Bell, A. Russell, F. W. Cork, F. Miller, C. L. Phillipps, E. H. Pascoe, H. G. Graves, A. V. Sam, A. H. Higby, P. H. Ashcroft, P. G. Vickers, W. J. Rees,

N. Miller, H. Chambers, Thos. Adamson, G. C. Leach, and W. Augier.

The following was then the order of the procedure:—

Proposed by Mr. Miller, and seconded by Mr. Ward, that Mr. Holland take the chair.

Mr. Holland having taken the chair, called upon the Acting Honorary Secretary to give a summary of the steps which had been previously taken with a view of forming a Mining and Geological Institute for India.

The writer gave a short account of the preliminary steps which had been taken to establish the Institute and of the proceedings at the informal meetings.

It was proposed by Mr. Hayden and seconded by Mr. Ambler that "an Institute to promote the cause of geology, technical mining and the allied sciences shall be formed. That it shall be called 'The Mining and Geological Institute of India,' that all those who have signed the forms issued by the Provisional Committee shall be regarded as original members."

It was proposed by the Chairman and seconded by Mr. F. J. Agabeg, that "the rules drafted by the Provisional Committee and now before the meeting, shall be the rules of the Institute, subject to any verbal alterations necessary when the proofs are revised."

The Chairman explained that the officers and members of the Council were nominated by the Provisional Committee after most careful consideration, with the object of having all classes, districts, and interests fairly represented.

He ruled that, "as this is an inaugural meeting, voting shall be done by show of hands."

It was proposed by Mr. McLeod and seconded by Mr. E. C. Agabeg that "Mr. T. H. Holland shall be the President of the Institute."

It was proposed by Mr. Grundy and seconded by Mr. Bathgate that "Mr. William Miller and Mr. Thos. Richards shall be Vice-Presidents as representing coal and metalliferous mining respectively."

It was proposed by Mr. Adams and seconded by Mr. Adamson that "Mr. R. P. Ashton be Honorary Treasurer."

It was proposed by Mr. J. P. Mackintosh and seconded by Mr. Graves that "Mr. W. H. Pickering be elected Honorary Secretary."

The President proposed and Mr. Miller seconded that "the gentlemen nominated by the Provisional Committee shall be elected members of the Council, *viz.*, Messrs. F. J. Agabeg, E. C. Agabeg, R. G. M. Bathgate, R. J Browne, G. M. Darby, Jas. Grundy, S. Heslop, H. H. McLeod, W. McFarlane, F. L. G. Simpson, A. S. Thomson, J. J. Turnbull, H. C. Veasy, T. H. Ward, and C. H. Richards."

All the above Resolutions were passed unanimously.

The President then took the chair, and after declaring the Institute duly formed, delivered the following address:—

Presidential Address.

BY

T. H. Holland, F.R.S.

YOUR HONOUR AND GENTLEMEN :—

It is my pleasant duty to declare that the Mining and Geological Institute of India has been, by the unanimous resolution of this meeting, formally established with the object of promoting "the study of all branches of mining methods and of mineral occurrences in India, with a view to disseminating the information for facilitating the economic development of the mineral industries in the country."

While congratulating the Members, most of whom are present, on the successful inauguration of the Institute, I have to express my thanks for the confidence you have shown in electing me to be your first President. He must be a feeble soul, who, conscious that he has received undeserved honours from his fellows, does not in some degree strive to reach the ideal which has been formed of him. Of all the feelings that have been engendered by the dignity you have thrust upon me, that of responsibility is, consequently, the most pronounced.

Just now I am painfully conscious of the circumstance, that in this first Presidential Address I am filing a specification, which, by the law of precedent, ties my successors to a custom they may wish to modify or abandon. But what evolution has done for the biological world it may do for Presidential Addresses, and if I bore you now for an hour, console yourselves with the thought that I am constraining many eloquent

successors to undertake a duty which they might otherwise wish to evade.

The occasion is, however, unique; and with the multiplication of societies, institutes and special corporations, a short preface is necessary to show who we are and why we came into being. My acquaintance with Indian Mining is what most of you would call theoretical; but I am in the position of the official spectators at the Greek games, the *theōroi*, from whom the name descended, being able to take an impartial view of all the players, and proverbially said to see the best of the game.

As our name implies, we are attempting to blend in our constitution the science of Geology with the art of Mining. Now, there are many people who believe that the union of a theoretical science with a practical art, even if possible, must result at best in sterile offspring. The idea is characteristically English, and is the outcome partly of an education in which the schoolboy's notion of science is limited to its application in the art of self-defence, partly to the circumstance that where science is taught the student is often crammed with the facts instead of trained in the methods; it is probably the latter class who have given the practical man his low opinion of theoretical training. The product of the science-class is often handicapped by what Huxley called "precocious mental debauchery," the results of many bouts of book-gluttony and lesson-bibbing. The student despises the practical rule-o'-thumb workers, because he is often unable to grasp the principles underlying the rule-o'-thumb; he is like someone said of the early riser, who is conceited all the forenoon and stupid for the rest of the day.

There is a tendency in England for the pure geologist to look askance at the man who takes up economic problems in mining. He seldom wholly disguises the feeling that the

mining man belongs in his mind to another caste, working at a lower level, "where the pure light of science is slightly dimmed by the smoke of commercialism." I am willing to admit that there are many faults on the side of us *theōroi*; that it will be for the good of our professional souls to get into competitive contact with practical men. Scientific work necessarily involves exercises in the practical verification of each theoretical deduction: practical mining is thus a perpetual scientific training, more so than the cramming of geological facts in the classroom. Representing that class of members whose practice is what most of you would call theoretical, I welcome the opportunity of having my theories tested by the fire-assay of financial result. I am thus in the position of the early riser who has passed noonday—I have lost my conceit, and wish to be saved from the afternoon of stupidity.

But what of the other side? Can you make any practical use of our geological theories and facts?

"The great end of life is not knowledge but action," and the Government have not maintained a Geological Survey for the last 55 years merely to know that Jurassic fossils occur in the Central Himalayas, or that the trap intrusions which have been such a pest in the coalfields are peridotites instead of lamprophryes, as they were once thought to be. The object in view is the development of the mineral resources of the country, and whatever my scientific friends may say, it is the duty of the Government and the duty of their scientific officers to make this the paramount object of scientific work in India.

But as to how this end can be reached most profitably in the long-run, there may be greater differences of opinion. A company with a small area under its control and a limited tenure would be justified in adopting a simple empirical search for valuable minerals, without regard to the scientific

problems which may crop up during the course of the investigation. The government of a large country, on the other hand, recognises the fact that the systematic study of the geological conditions in one part of the country gives a key for the more ready solution of problems in another, and systematic survey work consequently pays eventually, even if the search for valuable minerals is the only object in view. I am not prepared to admit this as the sole aim of scientific work: the intellectual product has a market value in a civilized community as well as the material product.

It is generally dangerous to say that a scientific investigation has no direct influence on industrial life. Faraday's discovery of the laws governing the relations between an electric current and a magnetic needle gave rise to the telegraph and telephone. Coming to our own time and place, and employing an illustration on a smaller scale, our curiosity regarding the constitution of the peculiar tropical weather-product known as laterite has led to the discovery of enormous deposits of aluminium-ore in India, used hitherto as building stone and road-metal.

In America, the mine-owners have learnt the value of Geology to Mining, and conversely geologists have discovered the use of practical tests for their scientific theories. As a consequence of the application of scientific methods, there is no industry in America which shows better average financial results than mining; the industry there has been methodized and governed by scientific laws. In a paper dealing with this question read before the Institution of Mining and Metallurgy, Mr A. G. Charleton stated "that whilst people in America invest in mines and gamble in rails, the English public gamble in mines and invest in rails."

In this country, there is a tendency to follow the English model, using methods which persist in the old country only

because vested interests there involved outweigh the disadvantages due to their continued use. We, however, do not even transplant the methods and machinery up-to-date, but lend ourselves to the acceptance of material about to be discarded in Europe. The adoption of schemes evolved by purely theoretical considerations might be dangerous, and might lead to many failures: on the other hand, the adoption without modification of methods suitable elsewhere, or about to be discarded in progressive countries, would be a certain handicap to any industry. As we have found in Indian Geology that our rock-groups cannot be classified by the European standard model, so also it must be in Mining. The conditions of mineral occurrences here cannot be exactly like those of Europe and America; and consequently the European methods of exploitation without modification cannot be the most economical methods to apply to the Indian deposits.

It is one of the objects of this Institute to correlate the isolated observations of independent workers in different parts of the country, and to accomplish for Indian Mining and mineral occurrences what has been done by Government for the general Geology of the country—to discover the local peculiarities of our mineral deposits, and to establish the working principles most suitable to the special conditions of the country.

Every form of business and profession suffers in some degree from the parasitic charlatan, but Mining, and more especially Mining Geology, gives him unusual opportunities. The English-speaking Anglo-Saxon nations, who possess the largest share of the World's deposits of valuable minerals, believe firmly in individualism, and, except where human life is concerned, have a racial antipathy to the imposition of legal definitions of efficiency in professional work. Doctors,

ship-masters and colliery-managers, who are entrusted with the care of human lives, are licensed by authority; but as far as the law is concerned, anyone is at liberty to call himself a mining expert, and those of his neighbours who undertake the public duty of criticising his assumption render themselves liable to the laws protecting individual liberty.

The very general deficiency of popular knowledge regarding the subjects involved in developing mineral industries; the frequent signs of kinship between Mining, especially metalliferous Mining, and lotteries; and the Anglo-Saxon's simple faith in the honesty of his neighbours, form the culturable medium on which the self-constituted expert flourishes. In his famous address to the British Association in 1870, Professor Huxley demonstrated the absence of known exceptions to Redi's doctrine of biogenesis; he showed that all known species have descended from living beings, that, *omne vivum ex vivo*, "there is no life without antecedent life." If he had lived in Bengal during the gold-fever of 1890, he would have been compelled to admit as an exception that the mining expert may arise by spontaneous generation; that his professional ancestry is as indeterminate as that of Melchisedec—without father, mother or professional descent. He springs up in any community at the mere mention of the word gold, and, as might be expected with acts of special creation, each specimen constitutes a new and independent species: one variety is able, from a black, porphyritic crystal of hornblende in an intrusive diorite, to predict the discovery of coal at greater depths; another knows that a particular area contains what he calls "great possibilities" from the general resemblance between his employer's property and some gold-bearing part of Australia, where his mining enterprise was probably limited to the contents of metalliferous pockets above instead of below ground; in extreme cases of specialization in the ancient art of

discovering mares' nests we have recently had illustrations published in the Indian daily newspapers, including the discovery of artificial alloys like brass, and, more wonderful, of carbide of calcium in a locality where the quarry-workers are hampered by an influx of water, whilst one prospector has announced the mysterious discovery of the radio-active axis of India! Some of these discoveries are inspired by true business instincts, whilst others, like the last-named, may be due to the radio-active influences in the tropics of a celestial, not a terrestrial, body.

The self-constituted expert knows that the public invariably prefers a definite statement to a cautiously given inference, and he is consequently able to give precise conclusions where the honest professional man sees justification only for further research. Hargrave, the commentator on English law, once said that "every lawyer who wrote so clearly as to be understood was an enemy to his profession." The ingenuity with which some so-called mining engineers hide their thoughts in the patois of science displays an equal solicitude for the interests of their brethren.

No mining community is wholly free from the parasite of this class: he is the specific bacillus of every gold "fever." It is impossible to exterminate the pest by the application of antiseptic Government regulations, without at the same time producing an undesirable inhibitory effect on the germs of healthy enterprise. Government regulations to check gambling in mining interfere also with legitimate risks; and Government measures to exclude doubtful mining experts would naturally interfere with the liberty of many honest prospectors.

These things are fairest when controlled by purely democratic institutions, and the formation of this Institute gives the mining community in this country an opportunity of setting up its own standard of efficiency in professional work. The

membership even at its inauguration is so well distributed, that any owner of mineral-bearing land in India would not be unjust in asking his prospector, mining engineer, or geologist, whether or not he is a member of the Mining and Geological Institute. We have no bar to membership but professional incompetence or imperfect moral development, and there will thus be in future two classes only of mining engineers outside the pale of this Institute—those who are unable to pronounce our simple shibboleth, and those who can produce as good a pass-word from a similar Institution elsewhere. Mining engineers of the latter class will be welcome to our hospitality.

From my position in the conning tower of mineral intelligence, it is easy to detect the signs of a rapidly growing interest in Indian minerals. Our production has increased by fifty per cent. in value during the past five years, the licenses and leases for prospecting and mining granted during 1904 were one and a half times those granted in any previous year, whilst the quarterly returns received so far from the Local Governments show that our record for 1905 will exceed even that for 1904. This rapid growth of interest in Indian minerals is, however, so far healthy, and, as long as the country's social and economic elastic limits are not exceeded, there will be no necessity to draw on the Government stock of ballast, which some of our investors describe as parental interference.

I have endeavoured to show that an Institute of this kind can do more than Government regulations to render the country unsuitable for the growth of that class of prospector who preys on the credulity of the innocent investor. My remarks so far refer to the preliminary stages in mine-development; but to secure efficiency of management in the later stages of actual exploitation is possibly even more important.

The two great arts on which mankind depend are agriculture and mining: agriculture is essential for our existence, our food and clothing; mining is necessary for the products on which our complex civilization depends. Now, the products reaped by the farmer are capable of unlimited reproduction, and the effects of bad farming form recoverable losses. But the harvest of the miner can be reaped but once in the history of the country and the world. There are no artificial fertilizers for exhausted mines; for exhaustion in a mine does not mean the simple removal of all the mineral of value; often, especially in coal-mining, it means merely the removal of the richest deposits, which will give the quickest returns, attended by the destruction of the second-rate deposits, which would be considered worth working if the richer material were not present in quantity sufficient for present requirements. We need not go beyond the limits of this coalfield for illustrations. Many of those present could furnish examples of thin or poor coal-seams destroyed for ever by the goaf-falls following the excavation of a thicker and richer seam below, and many more of you are blushing at the recollection of coal pillars lost for ever. Sir William Dawson calculated that a coal bed, one foot thick, represents about 50 generations of coal plants, and that each generation might be estimated to have required about ten years. Some of your 20-foot seams must have taken, therefore, 10,000 years to form. If the wasteful manager knew what it cost Nature to make a coal-seam, he would feel that his destructive methods are sometimes no more pronounced than would be the utilization of pearls for ordinary lime-burning. If this Institute should secure some degree of increase in efficiency amongst our mine managers, it will pay the owners of mineral rights and the Government to give it practical support. Our mineral resources can be used only once in the history of the race, and in the inevitable degradation of

potential energy which constitutes life it is our duty to avoid wanton destruction.

During the discussion with regard to the names of the distinguished men to whom we have decided to offer our Honorary Membership, our thoughts naturally recurred to that of Dr. W. T. Blanford, who, if he had lived another year, would certainly have been the first name on our list. No name has been so prominent in the literature of Indian Geology and Natural History, and none will live longer in the history of Science. His death last year removed one more, and now nearly the last, of the great names that constituted the heroic generation of Naturalists—the men who came to the front in the philosophic revolution that followed the publication of Darwin's "Origin of Species," and who made the latter half of the Nineteenth Century the most conspicuous landmark so far in the history of Biology and Geology.

If I were asked for a fitting memorial to the name of Blanford, I would reply in the words inscribed inside Sir Christopher Wren's greatest work, St. Paul's Cathedral—*Si monumentum requiris, circumspice*: "if you seek his monument, look around you." This great coalfield, on which, by a happy chance, we hold our Inaugural Meeting, is the outcome of the work of Blanford; this Institute is one of the bye-products of his genius. The survey of this field formed the subject of his first independent work. It was here that he worked out the classification of the coal-bearing Damuda series with a precision that has permitted of no revision after 45 years of geological research. It was here that he cut off the Panchet series above and confirmed the separation of the Talchirs below, circumscribing the stratigraphical horizons of workable coal. He thus laid the foundation principles of

coal-prospecting, principles which are followed still by drillers and miners who, in many cases, have not the slightest idea of when and how it was learnt that the appearance of the Panchets in a bore-hole mark the beginning of the coal-prospector's hopes, as on reaching the Talchirs he knows for certain that he has reached the stage below which coal never occurs in India.

If Blanford had done no more than establish a classification for the Gondwana rocks in Peninsular India, his cost to the country would have been returned many fold by the benefits secured to coal-prospectors. But he did more than that in this particular field. His memoir and map of the Raniganj coalfield have been the only geological guide of the colliery managers since its publication in 1860. Those who have attempted geological work in areas coverd with "paddy" fields and with deeply weathered outcrops can form some idea of what it meant to produce a map like that of the Raniganj field at a time when many of our seams were unopened, before the diamond drill was ever used, and when no one worried about mine-plans for the few shallow workings then in existence. Amongst the splendid pieces of survey work done by Blanford in every province, of the remarkable memoirs which secured for him the greatest honours at the command of the Scientific Community at home, if I were asked to name one sufficient alone to demonstrate that wonderful accuracy and precision of mind which were his leading traits, I would still say, "Look around you!"

During the past ten years, more than 25 million tons of coal have been raised in this field, with a pit-mouth value of about 4 million sterling. If we add to this the amount raised during the previous 35 years after Blanford's survey was made, and the many times larger quantities yet to come, we shall form some idea of how great an issue depended on the

accuracy of his field-work, and the soundness of his deductions.

No simpler or clearer illustration could be obtained anywhere of the value of geological science to the mining industry than that which is presented to us in this very field. And as this field has now been opened up to greater depths by the miner, and has been pierced in every part by the diamond-driller, we should be in a position now to extend our geological lines from where Blanford was compelled to stop, to fill in the details of a picture which he was naturally compelled to leave as an outline sketch. This Institute now provides the medium by which such work may be done, and if advantage is taken of the opportunity which is thus presented to our Raniganj members, this field will form an illustration also of the value of Mining to Geology. Even from what appears to be the purely theoretical point of view, there are many geological problems in this area for the solution of which the mine-managers have unusual opportunities. It is true that the scientific principle of to-day is the economic instrument of to-morrow: it is equally true that economic developments afford the means for the refining tests and for the revision of scientific hypotheses. I have shown that the first statement is illustrated on the very ground where, by chance, we hold our Inaugural Meeting. I leave it for our mining friends to take up the parable at this point, and to give us the benefit of the observations which form the inevitable accompaniment of their daily occupation. I suggest, therefore, the revision of the Raniganj geological map as the first problem for a Committee of the Institute.

I have referred to the way in which the Geological Survey has been compelled, at times, to break through the limitations imposed by European teaching and experience,

and have pointed the moral for mining men who may likewise be too readily inclined to regard the methods in which they were trained at home as suitable for universal application.

It is not an easy matter to depart from the traditions of early training, and it is never safe to deduce new principles from limited experiences. But amongst all the effects of a scientific training, the most conspicuous ought to be that which destroys cast-iron conservatism: science admits of no finality, and if the wider experiences of work in other parts of the world did not modify the principles laid down by observations in Europe, the science of Geology must have reached that stage in its evolution which immediately precedes degeneration.

It is possible that we may run along false lines in the development of geological science in India, but we certainly should be making mistakes if we adopted the European standard without modification. In a Department of Government, the promulgation of new schemes by its senior officer necessarily carries with it an implied order of compliance; but in an Institute of this kind we are all freemen, and I feel, therefore, that in offering for your consideration a new scheme of classification for Indian rock groups, I am not forcing any member, whether related to me officially or not, to accept more than arises as a legitimate deduction from undisputed facts.

In consequence of the way in which most areas on the Earth have been alternately immersed below the sea to receive deposits of sediment, and raised to the denuding action of atmospheric agents, the sedimentary record in every country is marked by interruptions at irregular intervals. These interruptions, or "breaks," are not on the same horizons for all parts of a large area; for one part may be below the ocean when another is raised above sea-level, and is being

eroded by the weather. The dominant breaks in the Indian stratigraphical scale can only, by an infinitesimal chance, be strictly contemporaneous with those in Europe. Life and the other processes of physical geology have been continuous on the Earth's surface since the beginning. The boundary lines between systems and groups of strata must, therefore, be purely arbitrary as far as the Earth's history is concerned. There could have been no time at which Palæozoic living beings ceased abruptly, and Mesozoic plants and animals took their places. The line in Europe between the Palæozoic and Mesozoic groups was fixed by a dominant break in the local record; but the gap must correspond to a continuous record somewhere else. In this somewhere else, therefore, there will be rocks in which the fossils are neither wholly Palæozoic nor distinctly Mesozoic; and, as might be expected, some of the bitterest controversies have arisen over the classification of these passage beds, where geologists have attempted to refer all new occurrences to the European standard scale.

If a dominant physical and palæontological break in India corresponded to a time of continuous deposition in Europe, it would be found, in attempting to employ European terminology in this country, that we should be grouping together above and below the break formations which are obviously the result of utterly unlike physical conditions. The application of the European scale of classification to Indian strata would, in the same way, result in the drawing of artificial separation lines within continuous conformable Indian series, thus artificially splitting obviously natural units.

The study of stratigraphical geology in any country is prosecuted with the intention, as one of its objects, of unravelling the natural history of the past. It is evident, therefore, that in each area the classification of the strata should

aim at an expression of the dominant features of that area. We lose just as much by attempting to express Indian stratigraphy in European terminology, as we lose by the translation of the works of a great classical author into English. In India, therefore, it is necessary to use a terminology which will give expression to a natural system of subdividing the local strata. The attempt to translate the Indian terms into those recognised in the European scale is in itself interesting ; but it is of secondary importance compared with understanding the local geological vernacular. When one sees a geological map of India coloured to correspond to such terms as Cambrian, Silurian and Devonian, one would be justified in regarding it as either the effort of an amateur, the result of a mere reconnaissance insufficient to develop a natural system of classification, or the attainment of perfection in translating our stratigraphical record into the terminology of Europe.

Amongst the fossils that we find in our Indian formations, only a small percentage corresponds specifically with those known in European rocks; further work in both areas will doubtless increase the precision with which we are able to correlate our horizons here with those in Europe; but we shall never attain perfection in correlation until we have solved all the doubts about the time necessary for migration and the evolution of each species: that goal is still infinitely far off, and there is no immediate hope of our being able to demonstrate contemporaneity between the beginning and finish of a definite formation in India with any stratigraphical horizon in Europe.

It is possible that during the course of the evolution of physical geology, there have been great changes which have had a widespread influence on the World's face, such, for instance, as the occurrence of a glacial epoch. But it is not likely that any change has been so marked as to be universal in its influence : the utmost we can hope for is to discover the

evidences of the changes profound enough to affect an area as large as India, and, in framing a scheme of stratigraphical classification for this country, to take these most marked lines as boundaries for our larger groups of strata, accepting the less marked and local interruptions as subdivision lines.

The scheme of classification shown in the accompanying table recognises the existence of three great interruptions in the Indian stratigraphical record. The oldest of these is that which marks off the fundamental complex of folded and foliated schists on the Peninsula from the old unfossiliferous systems known by such local names as Cuddapahs, Bijawars and Vindhyan. The fundamental complex below this break agrees in essential respects with that of Europe and America, where, on account of its great age, it is known as the Archæan group. What the great Eparchæan break represents in the geological time-scale we have not the slightest idea, but it is probably no exaggeration to say that the lapse of time since *Olenellus* flourished in the Cambrian seas is small compared with that between the formation of the lava-flows folded up in the Kolar goldfield in Archæan times, and the deposition of the basement sediments of the Cuddapah area after the great Eparchæan interval.

Table Showing the Classification of Indian Strata.

	Group	Marine formations	Freshwater formations.	Approximate age in European and American equivalents.		
FOSSILIFEROUS.	Aryan Group.	Raised beaches, coral banks.	Recent alluvium; Porbandar stone; Desert sand.	Recent	Post Tertiary.	Cainozoic
		Cuddalore sandstones	Older alluvium of Narbadā and Godāvari.	Pleistocene		
		Makrān series ...	Upper Siwāliks, Irrawaddy series.	Pliocene ..	Tertiary.	
		Gāj, Yenangyaung and Prome series.	Lower Manchhar	Miocene ...		
		Nāri . .	Kasauli .	Oligocene		
		Kirthar, Rānikot, Sabāthu	... .	Eocene		
		Cardita beaumonti beds ...	Deccan Trap ...	Cretaceous ...		Mesozoic
		Chikkim series; Bāgh beds; Ariyalūr, Trichinopoly and Utatūr beds.	Lameta series ...			
		Spiti shales; massive limestone of Baluchistān; Umia, Katrol, Chāri and Patcham series of Cutch; Hsi-paw series	Jabbulpore series. Rajmahāl and Mahādeva series.	Jurassic ..		
		Trias of Central Himālayas; Ceratite formations of Salt Range.	Pānchet series ...	Triassic ...		
		Productus shales and limestones, Central Himālayas and Salt Range	Dāmuda series	Permian ...		Palæozoic.
		Boulder-bed of Salt Range.	Tālcher boulder-bed.			
		Upper Palæozoic unconformity.				
	Dravidian Group.	Fenestella shales of Central Himālayas; Zewān beds of Kashmir; Limestones, etc., in Burma.	.	Carboniferous ...		
		Chitrāl limestones, Maymyo limestones.	. .	Devonian ...		
		Silurian of Central Himālayas; Namhsin and Zebingyi beds of Upper Burma.	Freshwater formations unknown between the base of the Gondwānas and the uppermost Vindhyans.	Gothlandian (Silurian.)		
		Haimantas in part of Central Himālayas. Naungkangyi and Nyangbaw beds of Upper Burma.	. ...	Ordovician ...		
		Neobolus bed and associated Cambrian in the Salt Range.	.....	Cambrian ...		
		Olenellus zone or base of the Cambrian system.	.....			

	Group.	Marine formations.	Approximate age in European and American equivalents.	
UNFOSSILIFEROUS.	PURĀNA GROUP.	Vindhyans, Kurnools, Upper Cuddapahs, Kalādgis, Pākhals, Bhīmas.	Keweenawan ...	ALGONKIAN.
		Lower Cuddapahs, Gwaliors, Bijāwars and Pengangā series.	Animikie ...	
	ARCHÆAN GROUP.	*Great Eparchæan interval.*		
		Dhārwārian	Huronian ...	ARCHÆAN.
		Eruptive gneisses and granites: charnockites and norites of Southern India; anorthosites of Bengal.	Laurentian ...	
		Schistose gneisses, often with intruded pegmatites like those of the mica-mining areas.	Keewatin ...	
		Oldest gneisses	Coutchiching ...	

The unfossiliferous rock-systems lying on the denuded edges of the Archæan gneisses and schists in Peninsular India, I propose to group together under the name *Purana Group*. We have no positive evidence with regard to the age of these systems beyond the fact that they are certainly older than the Permo-Carboniferous base of the Lower Gondwanas, and in the official Manual of the Geological Survey they have been referred to as "Older Palæozoic." But it is difficult to imagine that rocks so eminently suited for the preservation of organic remains as are the Cuddapah, Kurnool or Vindhyan shales and limestones could have been formed during that part of the Earth's history marked by well-preserved faunas and floras of the Lower Palæozoic era without including *some* traces of the life then in existence. They have certainly been searched as thoroughly and as carefully as most geological formations in the World, and have so far not yielded a single case of a recognisable organic structure. Under the circumstances, I consider we are justified in excluding these rocks from the inner circle of fossiliferous deposits, and in regarding them as pre-Cambrian in age—some of them formed

possibly before the appearance of life on the globe, and others when living beings did not possess structures sufficiently durable to outlast the subsequent changes in the rocks in which they were embedded. In parts of North America, there are rock-groups very similar to those we know as the Cuddaphas, Gwaliors and Vindhyans in Peninsular India; they are similarly, either quite unfossiliferous, or they include doubtful organic structures, and their age in America is known by positive observations to be older, at any rate, than the Upper Cambrian. In default, therefore, of fossil remains in rocks obviously most suited to their preservation, and with this American analogy before us, we are justified in regarding these rocks as pre-Palæozoic, and I propose to group them under the expressive name of *Purana*.

Unfortunately, on the Peninsula, where the Purana group is typically developed, there is no trace of the Cambrian strata, whilst in the Salt Range of the Punjab, where the recognisable equivalents of the European Cambrian occur, we have no exposures which can be identified certainly with the Purana systems. We are unable, therefore, to say whether the younger stages of the Purana group were formed before Cambrian times or not; we can only assert that the Purana group, as a whole, is probably older than the Cambrian of Europe.

In the Salt Range, there occurs a fossiliferous band of shaly rocks including forms closely related to those that mark the so-called *Paradoxides*-fauna, or Middle Cambrian System in Europe and America. From this stage onwards we are able to identify fragments of the European stratigraphical scale in various parts of India. But there is a well-marked interruption in the progress of events at a stage corresponding approximately to the Permo-Carboniferous of Europe. At that time the great austral continent, of which India formed

a part, became subjected to glacial conditions, and the well-known boulder-beds at the base of the Gondwana system and below the Productus limestone formations in the Salt Range were then formed. This well-marked horizon forms a convenient reference line in the fossiliferous scale: all the strata below it I propose to distinguish as the *Dravidian group*, all those above this line and younger, I would separate as the *Aryan group*, the names being used in a sense analogous to their use in ethnography and linguistics, the Dravidian in both cases being the older.[1]

We thus have four great groups of Indian strata—(1) the *Archæan*, whose name has been borrowed from America for the probable equivalent of the fundamental crystalline complex; (2) the *Purana*, a name we should be pleased to offer the Americans as a convenient means for escape from the civil war between their Algonkians and Huronians; (3) the *Dravidian*, or older division of the fossiliferous strata, and (4) the *Aryan* group, founded at the time of the Talcher glaciation.

In the table of strata now offered, the terms Palæozoic, Mesozoic and Cainozoic are placed in their probably equivalent positions; but their boundary lines, if extended to India, would cut through perfectly conformable series where no natural division occurs, and the terms are consequently inapplicable to Indian conditions. In the Salt Range and the Central Himalayas, we find strata with fossils related to the typical Permian of Europe passing up gradually, without any sign of physical break, and without any abrupt palæonto-

[1] A similar use of the terms Dravidian and Aryan was adopted by the late W. T. Blanford in his memoir on "The distribution of vertebrate animals in India, Ceylon and Burma" (*Phil Trans.*, Vol. 194, pp. 414, 415; 1901). The older fauna now represented by descendants amongst the reptiles and batrachians, distinguished as the Dravidian fauna, was partly displaced by the late Tertiary immigration of Holarctic types distinguished by Blanford as the Aryan fauna

logical change, into beds with undoubted Triassic fossils. The uppermost Palæozoic and the lowermost Mesozoic are thus not separated by a natural line; they form parts of a stratigraphical unit. In Baluchistan and Western India, too, we find beds with typical Cretaceous forms passing gradually into those with Lower Tertiary types: the division between Mesozoic and Cainozoic is thus also bridged over in India.

Our division of the fossiliferous scale into two groups forms a better-balanced classification than the three groups recognised in Europe, where the Palæozoic group is thicker and probably represents a much longer era of time than the later two taken together. This point is, however, unimportant beside the fact that the classification adopted marks off the most important periods in the physical history of the country. The classification I have adopted brings into prominence the three great interruptions in the Indian geological record. These interruptions were widespread in India, but I do not propose to yield to the temptation, always before the the author of a new system of classification, to extend the scheme beyond the area in which it is found to be a satisfactory working guide. If, however, this scheme is found to stand the test of criticism in this country, it is likely to be of assistance to workers in the existing parts of the old Gondwana continent of which India, Australia and South Africa are relics, and where the geological language is but a dialect of that suitable to India.

I have but a concluding word of advice to the Members of this new Institute. There is a tendency amongst English industrial men to be silent, if not secretive, about their business affairs. My experience shows that amongst mining men it is often the most ignorant who wish to hide their secrets

from others, assuming, apparently, that amongst them there may be some of value which might be turned to profitable account by others. I believe in the open door and absolute free trade in professional and scientific matters—perfect freedom with regard to the discussion of processes and results. Much of the development in America is due to the way in which professional men freely discuss their methods with strangers: there is no way of learning any subject thoroughly except by demonstrating it to others; and if by chance we impart original ideas to others by which they benefit, we invariably gain others by the effort of making things plain. Amongst his subtle thoughts contrasting the merits of candour and reserve, Bacon produced no antithetical maxim that neutralized the effect of these three:—"Silence is a virtue in none but confessors." "The silent man has no secrets told him." "Thoughts are like water, most wholesome when they flow."

His Honour the Lieut.-Governor of Bengal (Sir Andrew Fraser) proposed, and Mr. T. H. Ward seconded, a vote of thanks to the President for his address, to which he briefly replied.

The meeting then adjourned.

Inaugural Dinner and Speeches.

In the evening the members of the Institute dined together and all those who attended the meeting were present with the addition of a few guests.

The following speeches were delivered :—

The King-Emperor, the Prince of Wales, and the rest of the Royal Family.

The President, in proposing this toast, said :—

Your Honour and Gentlemen,—The Chairman of a dinner of this kind has one privilege over those whom he precedes in after-dinner speeches: he has the privilege of proposing a toast that needs no commendation. The health and long-life of King Edward would be a popular proposal not only in a British community, but in every country of the world. His Royal Highness the Prince of Wales has shown his interest in India by the long tour of inspection now in progress, whilst Prince Edward of York has commended himself to an Institute of this sort by a special request for a collection of Indian minerals. No other gathering could have better cause or greater pleasure in an expression of loyalty to the throne; and I therefore ask you to join in drinking to the health of the King, the Prince of Wales and the rest of the Royal Family.

The Mineral Industries of India.

Mr. W. H. Pickering, Chief Inspector of Mines in India and Hon. Secretary of the Institute, in proposing this toast said :—

It will be as great a disappointment to you all as it is to me, that an unfortunate illness should have prevented the Hon'ble Mr. J. P. Hewett coming here this evening, and that at the last moment I should

be obliged to propose the toast of "Success to the Mining Industry of India." Mr. Hewett has written as follows, the letter being dated Sunday the 14th :—

"I am very disappointed that the state of my health prevents me from being present at the inauguration of the Mining and Geological Institute of India at Asansol on Friday. I had much looked forward to meeting the members of the Institute at this inaugural meeting. The objects with which the Institute is being founded have the complete approval of the Government of India, and I should like to have had the opportunity of expressing publicly the good wishes of the Government for its success. The Government and the Institute are working with identical aims and objects in the development of the mineral resources of India, and the improvement of the methods on which mining conditions are conducted. We may, I venture to think, anticipate that the gentle guidance of the Institute will be able to effect improvements where the severer forms of discipline to which Government has to resort have not always been successful. I am delighted to hear that the Institute starts with so large a list of members actively engaged in the different mining industries of the country. It begins its existence under the most favourable auspices, and there can be no doubt as to its future success. With my best wishes for the prosperity of the Institute, and with my thanks to the members for having done me the honour to make me an honorary member,

I remain,
Yours sincerely,
J. P. Hewett.

This is a most encouraging letter. Mr. Hewett takes the keenest possible interest in Indian Mining, and I am sure it is the ardent wish of you all that he should have a speedy recovery from his prolonged and trying illness.

The toast which I have to propose is a most important one, for unless the Mining Industry develops so as to be in some proportion to this vast country, India will remain comparatively poor. Statistics, and signs more potent than figures, indicate that the industrial tide has begun to flow in India, and that if intelligent enterprise and energy are shown by those who are privileged to be pioneers, we are at the beginning of an era of such prosperity that has never previously been known in India.

In the year 1904, the total value of minerals produced in India was £5,357,840: to this gold contributed £2,366,079 and coal £1,398,826. The figures are, however, only valuable as additional indications and

for purposes of rough comparison, as spot prices and export values will fluctuate in sympathy with outside causes, and also are largely governed by the distances of the mines from the market, and by questions of carriage; but it may be noted, as a point, that for the past five years there has been an average increase of 7 % in the value of minerals raised. If we turn to the output of the minerals for which comparatively complete and trustworthy returns are obtained, we are on firmer ground. The most important of these minerals are:— gold, coal, manganese ore, mica and petroleum. The output of gold for the year 1904 was 618,746 ounces, and for the preceding year 603,787 ounces or an increase of 14,959 ounces. The output of coal for 1904 was 8,216,706 tons or an increase of 10·5 per cent. as compared with the preceding year; but if we go a little further back the advance of the industry is even more striking. In the year 1897 the output was only 4,066, 294 tons or less than half of that of 1904. Foreign coal then largely competed with the Indian coal, now it has been quite beaten out of the market. This true swadeshi success is welcome to us all. The development of manganese mining is even more remarkable. In 1893 the output was only 3,130 tons, and in 1903 it had risen to the record of 171,806 tons, and though it fell in 1904 to 150,297 tons, there is ample evidence that this is only a temporary set back. Unfortunately, nearly all the manganese is exported, and India does not benefit to the extent she would if it were used in her own manufactories.

The output of petroleum in 1898 was 22,234,438 gallons, and in 1904 it had risen to 118,491,382 gallons, and it is safe to prophesy that when the returns for the present year are received, there will be again a striking increase. The statistics also show that other mining is expanding in India, but it would be tedious to quote too many figures. Enough has been said to show that they give direct evidence of coming mining prosperity. There is also circumstantial evidence of equal if not greater weight. The prospector is active in all directions, and the capitalist, who has hitherto been strangely shy of Indian mining and kindred industries, is giving his attention to the possibilities of this magnificent country. Another encouraging sign of the times is that the Indian geologists, led by our President, have cut themselves adrift from the tradition that scientists should not be practical. The members of the survey go into the jungle as true prospectors with a keen eye for

minerals of commercial value, and though economic minerals loom large in the records of the survey, the interests of pure science are not neglected.

The development of gold mining is of great importance to the country. At present nearly all the Indian gold is raised in Mysore, and we may rest assured that the further development of these mines is safe in the hands of the enterprising engineers who have brought 6,000 horse power by duplicate electric cables to the mines from the Chauvery Falls, a distance of 91½ miles. There is ample evidence that equal enterprise will be shown at Dharwar, where a new gold-field is being developed.

The power of gold is great, but the door which leads to the true industrial prosperity of India must be opened with an iron key. The establishment of blast-furnaces and iron-works and the consequent expansion of coal-mining are essential. It is a good omen that the Barakar Iron and Steel Works are at last an assured success, and that a similar venture on a large scale will soon be launched. Agriculture is, and ever will be, the staple industry of India, but the coal-miner and iron-worker can help the agriculturist both directly and indirectly; directly by fertilisers from the bye-product ovens, basic slag, and mica waste, and indirectly by keeping the money in the country which is spent on imported iron and steel.

Important acts, rules, and orders regulating the working of Indian mines have come into force during the past few years, and others of even greater importance are foreshadowed; and it is believed that if they are administered and observed in a broad spirit, the effect will be to increase the general alertness and efficiency of those who are engaged in the management of the mines.

When I first mooted the idea of founding this Institute, one objection that was raised was that mining men as a rule were only temporary residents in India, and that it would be difficult to establish an *esprit-de-corps* amongst them. This magnificent meeting completely wipes out that allegation and shows that the Indian mining engineers and geologists are animated by public spirit and are anxious, like good citizens, to give their services to public work. If this were not so the future would be black indeed, for unless we are prepared to unselfishly sow for posterity, we are untrue to our trust, and this movement for the

benefit of Indian mining is in the wrong hands. I have to couple the toast with the name of Mr. H. H. McLeod, who is one of the most public-spirited men in the Indian Mining world. His work as one of the organisers and as the present Chairman of the Indian Mining Association is known to you all; he is also the head of the largest, and I believe the oldest, colliery company in India, and I ask you to drink the toast of the Mining Industry of India coupled with the name of Mr. H. H. McLeod.

Mr. H. H. McLeod, Chairman of the Indian Mining Association, said, in reply:—

When I received the honor of being asked to reply to the toast which Mr. Pickering has so eloquently proposed, I realised that the task was an onerous one by reason of the wide scope of the subject.

It is a far cry from Baluchistan to Singareni or from the gold mines of Mysore to the rich coal deposits of Assam; but this roughly represents the area of country within which the mineral deposits of the country are being worked.

My knowledge of the working of minerals other than coal is extremely limited, but the part that coal plays in connection with all forms of metalliferous mining, justifies the prominence which it invariably secures; and even the gold mines of Mysore, with their reserve of natural power, are partially dependent on coal for the recovery of the precious metal.

With the recent discovery of rich iron ore, the manufacture of iron and steel on a large scale, with all its great contingent possibilities, should be accomplished in the near future, and coal, in one or other of its forms, is essential for their successful production.

With the collieries of Bengal I am more intimately acquainted, and their preponderating influence on the country and the empire must be my excuse for limiting my remarks more particularly to that branch of the mining industry of India. I am relieved to think that little language is necessary on its behalf. It speaks so eloquently for itself. Evidence of its vitality is to be found within a wide radius round this country side; in the numerous chimneys dotting the horizon, in the twinkling coke-fires by night, and in the ceaseless throb of machinery at all times. If its sign-manual is to be found in somewhat

smoky characters across the sky, it is merely the ripe product returning to the atmosphere the same constituents it absorbed, as growing vegetation, many thousands of years ago.

It is far from my intention to weary you with figures, but it must not be forgotten that the coal industry has reached its present proportions from very small beginnings.

From the old records of my own Company, I find that 45,000 tons, or expressed in maunds, 12½ lakhs, were raised during the year ending September 1848. The whole of this quantity was transported in boats, a fleet of over 1,500 being required for the purpose. The E. I. Rly. came into being a few years later, but the rates of freight were considered prohibitive, and for quite a number of years water-carriage competed successfully with the Railway. To come down to more modern days, 1,380,000 tons were raised in Bengal during the year 1888. The Jherria Coal Field was responsible for 14,800 tons in 1894. Ten years later, it subscribed 2,880,000 tons to the total output of Bengal, which reached nearly 7 million tons.

The total output of coal from the mines of Assam, Bengal, Baluchistan, Central India, and Singareni, for the year 1904, amounted, as Mr. Pickering has remarked, to 8,216,000 tons. The exports from Kidderpore Docks in 1894 amounted to only 38,000 tons. They exceeded 2,400,000 tons for the year just expired. Bengal coal is well established in the markets of Burmah, The Straits Settlements, Sumatra, Ceylon, Mauritius, Aden, Bombay and Karachi, and at the present moment Hongkong is indenting largely on Bengal for its requirements.

As you are aware the coal industry has many difficulties to contend with, but the labour question and the equally important one of rolling-stock dwarf all others. When wagons are plentiful—which is extremely rare—the miner is generally employed in cutting paddy or in the more exhilarating pastime of drinking toddy; and when stocks have accumulated to an uncomfortable degree, the wagons vanish into thin air. At the present moment we are seriously thinking of organising a search party to look for the vanished rolling-stock of the East Indian Railway.

As regards the labour difficulty, our good friend, Mr. Hewett, is devoting much of his time and energy to solve this problem for us; but I feel convinced that a partial remedy lies in the adoption of mechanical

coal-cutting plant. The pioneers, who have experimented in this direction, deserve the greatest credit, and we must persevere to this end, ignoring irresponsible and ignorant criticism, remembering that success is invariably built upon failure.

So much for the commerical aspect of the coal industry. As regards its technical aspect, there are many round this table more qualified than myself to speak of the progress made. A great stride has been made from the old-fashioned "Gin" worked by women, to the finished equipment of a first-class colliery of to-day; and in this latter respect no better example could be obtained than the fine colliery we visited this morning at Charanpur.

Finally, if we should be permitted to raise the curtain and peep into the future, what should we see? What great possibilities await an industry which has already developed with such rapidity that it is sorely taxing the resources of two Railways and a wealthy Port Trust?

We may find that a partial solution of the transport difficulty is in store for us, the coal being carried to large central stations and its energy transformed into power gas or electricity, and in this form translated to the great industrial centres. That this is not the baseless fabric of a vision is demonstrated by the trend of movement now taking place in England. Whatever the future holds for us, no spirit of optimism is necessary to predict not only a great but a brilliant future for the mining industry of India. The country possesses practically inexhaustible mineral resources, and if any guarantee were required that the brains and energy necessary for their development will be forthcoming in the future, as hitherto, it is surely evidenced in the formation of the Institute you have so successfully inaugurated this evening.

It is therefore with an abiding confidence in its future that I thank you on behalf of the Mining Industry of India for the cordial manner in which you have responded to the toast.

The Mining and Geological Institute of India and its first President.

Sir Andrew Fraser, Lieut.-Governor of Bengal, in proposing this toast, said:—

Gentlemen,—I rise to propose the Mining and Geological Institute of India and its first President. I am not quite certain where I stand because the byelaws of the Institute have not yet been framed. They are to be framed by the Council which has been appointed to-day. My position and fate are in their hands. I belong to class D under Rule 3. In this body, which has been created to-day, there are (*a*) the ordinary members at the heart of things; (*b*) the associate members near them; (*c*) the associates apparently a little further out; and (*d*), on the very fringe or extremity, the Honorary members. I presume that that is the reason why I have been selected to propose this toast. I am not supposed to be a member of the Institute in quite so direct a connection with its life as the other classes of members are. I accept the position; but I desire to point out that Rule 3 distinctly says that the "Institute shall consist of" all four classes of members; and I comfort myself with the reflection that a strong arm and firm hand cannot conveniently part with the little finger, and would not if it could. I hope that when the Council are framing the byelaws they will take their stand on the word "consist."

It is a great satisfaction to me to have been here to-day. I have enjoyed the day from beginning to end. What a full day it has been, and how pleasant at every stage! When I woke, I revelled in the coolness of the morning and brought all my blanket power to bear on me. I was, a little later, carried at ease by our then host, Mr. Agabeg, on his trolley and locomotive to visit two pits; and when I descended the pit "Apcar" and was led about this apparently pathless subterranean wilderness by my guide, Mr. Patterson, I felt as if I was coming into close contact with the mining industry; and under their efficient tuition I could not but learn something about it. Then, when I sat down to breakfast at the hospitable board of Messrs. Apcar and Co., and saw around me a large gathering of those who are engaged in practical mining work with a small sprinkling of Inspectors and scientific men, I felt that I was brought into association with one of the very best Swadeshi Companies I had ever seen or heard of—men engaged in development of the resources of the country. May I add that when my health was kindly proposed and cordially received, I felt pride and happiness. I am not so blind as to believe that the enthusiasm with which that toast was received was entirely personal; nor am I so unwise

interested. It is good to find that the Director of the Geological Department is not a lifeless fossil, that the Inspector can eat and drink and enjoy himself, and that the Lieutenant-Governor, though he no doubt ought to be, and is, a solemn man, enjoys a gathering like this more than he can well tell you. May I be allowed specially to emphasise the importance of bringing the Honorary members (namely the Lieutenant-Governor, the Hon. Member in the Department of Commerce and Industry and the Chairman of the Mining Board) into contact socially as well as officially with the mining community. I am sure we all very much regret the Hon. Mr. Hewett's absence to-day. Mr. Hewett is a man who, by his deep interest in the industrial and commercial concerns of the empire and his close touch with the industrial and commerical communities, has conferred honour on the service to which I belong, and is an example to its members. I speak not only for him, but also for Mr. Walsh and for myself, when I say how greatly we value anything that brings us into touch with the mining community. I have been told that I have conferred a favour on the members of the Institute by coming down here to-day. It is very kind of them to take such a view. But for myself I regard this day's proceedings not only as a great pleasure, but also as of greater value to me than many a day that I spent over files in my office room.

It gives me great pleasure to propose that toast which has been entrusted to me: all success to the Mining and Geological Institute of India; and it is with great pleasure that I associate this toast with the health of its first President. I shall say no no more about Mr. Holland than I have already said to-day. I do not require to make any appeal to you to drink heartily to his health. All that I require is to ask you to do what I do myself with great satisfaction, namely to look back upon the events of this day. The young Institute which has been inaugurated to-day has been worthily inaugurated through the efforts of Mr. Holland and his coadjutors. It has inspired enthusiasm in all, and has been started on its career with an inaugural address of great value. I give you the toast of the Mining and Geological Institute of India and Mr. Holland.

The President, in reply, said:—

Your Honour and Gentlemen,—I am reminded just now of the remark made by Thackeray, that with regard to after-dinner speeches the

most remarkable feature is the extraordinary way in which the brilliant thoughts that occurred to one before, disappear during the course of dinner. The eloquent speech from His Honour, and the enthusiatic way in which you have responded to his proposal, have successfully removed the last traces of what I intended to say to you when I came. I am not likely to forget, however, the ready way in which you have replied to Sir Andrew Fraser's generous proposal of my health, or the encouragement which the promoters of this Institute have received from His Honour's unflagging interest in the long and trying programme he has shared with us to-day. But I cannot accept the kind things that have been said except in the name of the Institute, and of those who have shared the work of inauguration. If it is unwise and insubordinate to differ from the Lieutenant-Governor in questions of judgment, it would be dishonest not to correct him in matters of fact. I wish, therefore, to revise the statement that, in the founding of this Institute, I have not been seconded by the efforts of Mr. Pickering. The tandem order was quite the reverse. Mr. Pickering has given the inspiration and done the subsequent work of development, whilst I have merely been a feeble second, faintly applauding his efforts. He came to this country a year ago, and found dried bones of a previous abortive Institute, and being a practical man as well as a prophet, he proceeded to moisten the dry bones before prophesying, and the result is this vigorous army of mining men. When the proposal was first made to found an Institute of this kind along the lines of those in London and the North of England, we were met with sympathy on account of the objects in view; but in some cases the sympathetic interest was tinged with scepticism with regard to the possibility of our new Institute being comparable to those at home. I find, however, that on the day of our inauguration, two months after the project was first launched in this room, we have a membership already larger than that recorded at the end of first year's life of the Institutions which we claim as our models. Our future development is naturally bound up with the development of the mineral industries in this country. Mr. Pickering has already shown you by figures that there is a distinct upward trend in the curve of mineral development. He has told you also that there are other signs of development as unmistakeable as figures, and one of these, recently come to our

notice, is the fact that in some parts of India, my movements, and those of my officers, are traced by spies on the assumption, apparently, that we are not likely to collect specimens in places except those containing valuable minerals, and the information so obtained by the spies forms the first step in prospecting by certain enterprising persons in India. If this form of detection were not persisted in, I should begin to feel like the President of a South American Republic, who lamented the decay in the patriotic political feelings of his people shown by the fact that he had not been shot at for a whole fortnight. I was amongst those who wondered if the time were yet ripe for the foundation of such an Institute as this. I had seen failures before, and was easily daunted; but Mr. Pickering's enthusiasm and energy were not so easily damped. He refused to sit down and contemplate the cost of the undertaking, and I feel now that his success shows that it is not always wise to count the cost of a new enterprise; it is often more costly to do nothing than to go ahead without an estimate.

I should like to take this opportunity of welcoming, on behalf of the Institute, the two Mining Instructors who have come out at the request of the Bengal Government to arrange for systematic training in the principles of mining on the coalfields, as well as in connection with the classes at the Sibpur Engineering College. By their employment the Bengal Government has shown its interest in the industry, and its desire to give everyone a chance of improving his efficiency. The Lieut.-Governor has shown his personal interest in the special work for which this Institute has been founded, by his personal attendance and his eloquent sympathetic speeches in the course of the inauguration ceremonies. The Hon'ble Mr. Hewett has shown the interest of the Government of India in our scheme by the message sent through our Secretary, and by a promise he has made to back a proposal for a Government prize to be offered each year for the best paper read before the Institute. Finally, the Viceroy has given his cordial approval of our efforts and has accepted the office of Patron. It was Lord Minto's grandfather who was the first Governor-General to take up the question of mining Bengal coal, and ordered an investigation of the Raniganj coalfield in 1808. Perhaps the acceptance of the office of Patron of this Institute by

His Excellency may prove to be an equally important mark in the history of Indian Mining.

Chota Nagpur Mounted Rifles.

Mr. R. P. Ashton, in proposing this toast, said :—

Mr. President, Your Honor,—I think that before I speak on behalf of the Institute, I must thank the members of the Institute for allowing me to be one of their number. It is an Institute of scientists and scientific engineers, and I, alas, am only an amateur. I much appreciate this honor. Now I ask you, my fellow-members, to testify the thanks of the Institute to Captain Agabeg and the Officers of the Chota Nagpur Mounted Rifles for allowing the infant Institute to be cradled in this building. I have long been a supporter of volunteering, and for 13 years I was an active gunner, and so I speak with sympathy, and am glad that those who do not sympathise should see concrete instances of the good which the co-operation of efforts, which is engendered by the volunteer movement, leads to. There is the value to the individual besides the value to the State. One word more. In a body such as the Chota Nagpur Rifles, we have an organised force placed at the disposal of the State of far greater value than its value as a body of mobile riflemen, great, as I have no doubt its efficiency is, inasmuch as it contains so much of the scientific element represented in this room—an element of the greatest value in old and modern war. Who has not read of how, in the heroic defence of Lucknow, the Cornish miners of the Cornwall regiment—the Old 32nd—successfully met mine with countermine, and finally blew into the air Johannes house, and in later years how the mining engineers at Kimberley kept the enemy at a distance with a big gun made by one of them in the mines workshop? How the engineers of Japan mined and sapped Port Arthur we know. I need not say more. I hope the Chota Nagpur Mounted Rifles will never be called on to carry out such duties; if they are, I am sure they will carry them out well. To-day we have to thank them for building us a house not for blowing one up, and I ask you to join me in drinking to their prosperty in peace as in war.

Captain F. J. Agabeg, in reply, expressed the great pleasure it gave him and the Chota Nagpur Mounted Rifles

to welcome the Mining and Geological Institute of India to the Club. He had always advocated the formation of such an Institute, for he was a firm believer in united effort and he was delighted to see such a splendid gathering of mining men. Some of those present were members of his corps. He asked them to stand up, and when they did so, it was surprising to see that a large number of those present were members of the Institute as well as of the Chota Nagpur Mounted Rifles. He urged the others to join the corps as he considered that every able-bodied man in India, especially in the mining districts, should be trained in the use of arms. The very valuable machinery and other property at the collieries could easily be destroyed by rioters, and it was essential that trained men should be ready to muster for its defence at a moment's notice. Mining men made good soldiers. He gave several instances of the alertness and skill of the mining members of his corps in planting the blasting charges designed to blow up bridges, etc. He also told several amusing stories with reference to their care for commissariat. He sketched the rise and progress of the corps which was one of the most efficient in India. They had triumphed over the initial difficulty of want of funds, and the heavy cost of the club building in which they were gathered that night had been met. This was an example of what might be done by united and persistent effort, even in India. He now intended to have another large room added to the club. He wished the Mining and Geological Institute every success. He would do his utmost to help it, and hoped to again have an opportunity of welcoming the members at the Chota Nagpur Mounted Rifles Club.

Our Guests.

Mr. William Miller, Vice-President, in proposing this

toast, expressed the pleasure it gave the members to entertain their distinguished guests. It was most encouraging to the newly-formed Institute that Sir Andrew Fraser, Mr. E. H. Walsh and the other invited guests had remained with the members for a very long day. He coupled the toast with the name of Mr. E. H. Walsh.

Mr. E. H. Walsh, in reply, said:—

Mr. President, your Honor, and Gentlemen,—I appreciate the honour which the Mining and Geological Institute of India have done me in asking me to return thanks on behalf of the guests this evening. I do so with very great pleasure, not only on behalf of myself and my fellow-guests for the cordial hospitality that we have received, but also as one who takes a very great interest in the Mining and Geological Institute of India. As Chairman of the Mining Board during the past year, I have had the opportunity of becoming acquainted with questions concerning the mining industry and the rules of its management, and by visiting some of the pits, both those in which older and newer methods are employed, have tried to learn something of its details, and I feel sure that this Institute will be of the greatest assistance both to the managers in their work and to the mining industry in its development and advancement. Speaking for myself, as Chairman of the Mining Board, I may say that it will be of great assistance to me in enabling me to meet the managers of the mines, and to hear the views of the men who possess practical knowledge on subjects that may come before me officially. I think that it will be of assistance both to its members individually and to the mining industry generally, and that they will always be grateful to Mr. Pickering and Mr. Holland, its first President, for its inception. I congratulate them both on the successful issue of their undertaking. I will not detain you further. The Mining and Geological Institute of India has been born into the world to-day, and to judge from its first infant cry which we have heard this afternoon, bids fair to be a strong and sturdy youngster. On behalf of myself and my fellow-guests I wish it many happy returns of this, its birthday.

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I.—INTRODUCTION.[1]

1.—Nature of Manganese.

Manganese in the elementary form is a metal belonging to the iron group of elements, comprising iron, manganese, cobalt and nickel, which, owing to their more or less similar chemical habits,

[1] For a very interesting treatment of the subject of this section, and of the uses of manganese, see R. A. F. Penrose, Jr., *An. Rep. Geol. Surv. Arkansas for 1890*, Vol. I, "Manganese: Its Uses, Ores, and Deposits," pp. 1–56.

often occur in association in nature. When pure, metallic manganese is said to be of a greyish-white colour. It is extremely hard, cutting both glass and hardened steel. In the following table some of its physical constants[1] are compared with those of the other members of the group of elements to which it belongs :—

TABLE I.

Physical constants of the manganese-iron group of elements.

	Symbol.	Atomic weight.	Specific gravity.	Atomic volume.	Specific heat.	Melting point.
						C.
Manganese	Mn.	55·0	8·00	6·9	0·110	1245°
Iron	Fe.	55·9	7·86	7·1	0·114	1600°
Nickel	Ni.	58·7	8·80	6·7	0·108	1470°
Cobalt	Co.	59·0	8·80	6·7	0·104	1530°

2.—Origin of the Name.

Manganese does not, however, occur in nature in the metallic condition, but in combination, usually in the form of oxide, manganate, carbonate or silicate. Pliny considered manganese oxide to be a variety of magnetite or lodestone, which he called *magnes*. In the middle ages both the black oxide of manganese and the white oxide of magnesium were known as *magnesia*, being distinguished as *magnesia nigra* and *magnesia alba* respectively. From *magnesia nigra* the word *manganesium*, our modern *manganese*, is supposed by some to have been derived by metathesis or interchange of letters.

[1] Roberts-Austen, "An Introduction to the Study of Metallurgy," pp. 72, 73, (1898), with several alterations in accordance with later research.

Until 1740, when Potts[1] distinguished the two, the salts of manganese were confounded with those of iron; but it was not till 1774 that it was suspected by Scheele[2] that a metal existed in *magnesia nigra;* this was isolated two years later by Dr. Gahn.

3.—Distribution in Nature.

Of all the elements manganese is one of the most widely distributed throughout the three kingdoms of nature. It is, to a large extent, co-extensive with iron.

Mineral kingdom.—Of the 900 to 1,000 species of minerals now known to science about 100 of them contain manganese as an essential constituent, while many more frequently contain it in less important quantities. Most of the rocks of the earth's crust contain it, though usually only in small quantities, and it has been calculated by F. W. Clarke[3] that 0·10 % of the earth's crust consists of manganese protoxide (MnO), manganese ranking as the fifteenth most important element in this respect. As the result of the decomposition and denudation of the earth's surface by meteoric agencies, its various constituents get carried either in suspension or solution to the sea. It has been estimated[4] that one cubic mile of average river water contains in solution 5,703 tons of manganese sesquioxide (Mn_2O_3), and that 6,524 cubic miles of river water are annually dischaged into the sea.[5] This means that about 37,000,000 tons of Mn_2O_3, containing nearly 26,00,0000 tons of metallic manganese, are annually brought by rivers into the sea. This manganese becomes deposited at the bottom of the ocean in the form of the concretions so abundantly

1 "Examen chymicum magnesia vitrariorum, Germanis Braunstein" (Roscoe and Schorlemmer), Vol. II, Part II, p. 2, (1879). [(Penrose).

2 Stockholm Memoirs, 1774, [Kongl. Svenska Vetenskaps-Akademiens Handlingar]

3 *U.S. Geological Survey, Bulletin* No. 228, p. 19, (1904).

4 Murray, *Scottish Geographical Mag.*, III, p. 77, (1887).

5 Murray, *op. cit.*, IV, p. 41, (1888).

dredged up in nearly all deep-sea exploration work.[1] Manganese is also sometimes found in meteorites.

Animal kingdom.—Manganese "is said to form an essential constituent of the tissues and of the red corpuscles of the blood in the human body, being present in the proportion of one part of manganese to twenty parts of iron."[2]

Vegetable kingdom.—Manganese has been found in the ash of many plants, amongst which may be mentioned tea, coffee, potatoes, tobacco, wheat, grapes, and many other vegetables, fruits, and cereals, as well as in the ash of many woods.[3] To test the latter I had a bamboo cut from the top of a laterite hill in the Central Provinces. It was divided into short lengths, the outside cut off and rejected and then 533·5 grammes of the wood were incinerated in a platinum crucible yielding 8·8 grammes of ash of a bluish-green colour, and thus testifying to the presence of manganese in the bamboo.

II.—MINERALOGY AND GEOLOGY.

1.—The Minerals and Ores of Manganese.

List of Indian manganese minerals.

The recent investigations into the Indian manganese-ore deposits have led to the discovery of several manganese minerals new to India and not a few new to science, though these latter have not yet been thoroughly worked out. The following list enumerates all the Indian manganese minerals at present known :—

Oxides.—Dysluite.
Manganmagnetite.

---

1 See especially :—*Challenger Reports*, Vol. on Deep-Sea Deposits, (1891).

2 Penrose, *loc. cit.*, p. 2.

3 Penrose, *loc. cit.*, p. 2.

Jacobsite ?
Hausmannite ?
Braunite.*
Pyrolusite.*
Manganite.*

Manganates.—*Hollandite* and other manganates of Ba, Ca, Mn and Fe corresponding to the formula $R_2 Mn O_5$.
Psilomelane.*
v. Wad.*

Carbonates.—Ankerite ?
Rhodochrosite.*

Silicates.—*Blanfordite*
Manganhedenbergite } Manganese-pyroxenes.
Rhodonite * }
Two other }
Winchite — Manganese-amphibole.
Spessartite * } Manganese-garnets.
Aplome }
Piedmontite * — Manganese-epidote.
Carpholite ?
Two or more — Manganese-micas.

Phosphates.—Triplite.
Niobates.—Columbite.
Tungstates.—Wolfram.

Of the above minerals, dysluite, ankerite (?), aplome, triplite, columbite and wolfram have not been found in association with the Indian manganese-ore deposits and hence require no further mention here.

New minerals.

Amongst the collections of minerals from the manganese-ore deposits, several species and varieties have been found which are apparently new to science; but the only ones which have been sufficiently investigated to be named are those shown in italics in the above list.

Hollandite.—This mineral occurs in the crystalline form in quartz-veins traversing the manganese-ore deposit at Kájlidongri, Jhábua State, Central India. The mineral is greyish-black or quite black with a shining metallic lustre and has a hardness of 6 on the crystal faces and 4 on the striated fracture surfaces. The streak is black. The crystals in their simplest form show what looks like a tetragonal prism surmounted by a flat tetragonal pyramid ; but the few angular measurements yet made indicate that the mineral is either orthorhombic or triclinic, more probably the latter, and in either case very closely approaching the tetragonal form. The striations on the prism faces parallel to the vertical axis and the dullness and imperfect character of the pyramid faces have up to the present prevented this question being finally settled. An analysis of a picked sample of this mineral, kindly carried out by Mr. Howard J. Winch, manager and chemist to the Kájlidongri quarry, gave the following result :—

	Per cent.	
Silica (SiO_2)	traces.	
Ferric oxide (Fe_2O_3)	10·56	
Alumina (Al_2O_3)	0·94	
Baryta (BaO)	17·59	
Manganese peroxide (MnO_2)	65·63	Mn. = 45·45.
Manganese protoxide (MnO)	5·12	
	99·84	
Specific gravity	4·95	

This analysis corresponds to the following formula :—

$$m\,(Ba,Mn)_2MnO_5 + n\,(Fe,Al)_4(MnO_5)_3$$

or $$m\,(Ba,Mn)_2MnO_5 + n\,Fe_4(MnO_5)_3$$

according as the alumina be considered an essential constituent or not.[1]

For this new mineral I propose the name of *hollandite*, after Mr. T. H. Holland, F.R.S., Director of the Geological Survey of India, and President of this Institute.

I have found a similar mineral in the, at present unexploited, manganese-ore deposit of Sitapár, Chhindwára district, Central Provinces. It occurs in intimate association with five other minerals, none of which have yet been specifically determined, except pyrolusite pseudomorphous after manganite. It has no crystal faces developed, but is otherwise indistinguishable in appearance and hardness from hollandite, the especially characteristic feature of both minerals being the ready way in which they split along very striated planes parallel to the vertical axis. An analysis of a specimen of this mineral having a specific gravity of 4·70 has shown that it also is a manganate of barium, iron and manganese, with a considerable proportion of calcium.

Both these manganates correspond to an hypothetical acid H_4MnO_5, and there is probably a whole series of compounds derived from this acid by isomorphous replacement. Lespeyres[2] has already suggested that psilomelane may conform to this formula of H_4MnO_5 and the analyses Nos. 1, 3 and 4, of some Indian ores, on pp. 47 and 48, *Rec. Geol. Surv. Ind.*, XXXI, (1904), fit in almost exactly with this assumption, the NiO, CoO and Al_2O_3 being also calculated into the formula. Hence we see that there is reason to

[1] Mr. T. R. Blyth, Assistant Curator, Geological Survey of India, has been recently engaged in examining this mineral in a more critical fashion than was possible to Mr. Winch in his rough jungle laboratory, and finds that it contains, besides the constituents found by Mr. Winch, small amounts of lime and magnesia and of one of the rare elements.—June 24th, 1906.

[2] *Rec. Geol. Surv. Ind.*, XXXIII, p. 232, (1906).

[3] Dana's "*System of Mineralogy*," p. 257, 6th Edition.

remove psilomelane from the oxides and to form a new group of minerals corresponding to the hypothetical acid H_4MnO_5, and that these minerals are perhaps to be regarded as derived by isomorphous replacement from a manganese manganate, Mn_2MnO_5, as yet undiscovered.

This new group, the *manganates*, will contain hollandite, psilomelane, and the Sitapár manganate.

Blanfordite.—A second very interesting mineral is a pyroxene found in the Kácharwáhi manganese-ore quarry, Nágpur district, C.P. It is notable for its striking and beautiful pleochroism, which even in thin sections is—

$\mathfrak{a}$ = rose-pink,

$\mathfrak{b}$ = bluish lilac,

$\mathfrak{c}$ = sky-blue.

In thick sections the $\mathfrak{a}$ and $\mathfrak{c}$ axis colours are deep carmine and very rich sky-blue respectively. When fresh, the pyroxene is deep crimson as seen in hand specimens, but it is often altered so as to be chocolate-brown in colour. The mineral is monoclinic, with a small angle of extinction. The crystals noted below show three forms, the prism, clino-pinacoid and clino-dome, and sometimes exhibit basal parting planes best seen in thin sections under the microscope. In sections at right angles to the acute bisectrix a figure can be obtained, but points of emergence of the optic axes lie outside the field of view of the microscope. The specific gravity (as determined with some minute fragments and Sonstadt's solution) is 4·15. Before the blowpipe the mineral fuses easily to a black bead, gives a marked sodium flame and with fluxes gives indications of small quantities of manganese and iron. It occurs partly as a pyroxene-braunite-rock with interstitial apatite, and partly in aggregates and scattered crystals up to an inch long in a rather coarsely crystalline albite-rock. I propose to call this mineral *blanfordite*, after

the late Dr. W. T. Blanford. What is probably the same mineral was also found at Rámdongri, where it occurs in the manganese-ore body in a patch of what must be regarded as a granitic intrusive. This rock is of rather fine grain and is composed of microcline, quartz, plagioclase, and perhaps orthoclase, with some apatite, zircon and brown mica. Monoclinic pyroxenes having exactly the same scheme of pleochroism as blanfordite, but in much paler tints, also occur at Kájlidongri, Jhábua State, C.P., and Jothvád, Nárukot State, Bombay. This scheme of pleochroism can with convenience be designated the *blanfordite type of pleochroism.* These pyroxenes are perhaps related to that from the manganese mines of St. Marcel, Piedmont, Italy, described by S. L. Penfield,[1] as showing a very faint pleochroism in very pale rose and very pale blue.

Winchite.—This is the name which has been bestowed, after Mr. Howard J. Winch of Meghnagar, Central India, upon the blue amphibole from Kájlidongri, Jhábua State, concerning which a preliminary note has been published in the *Records, Geol. Surv. Ind.*, XXXI, p. 236, (1904). An analysis of this mineral shows it to be closely allied to tremolite in chemical composition, but to contain in addition oxides of iron, soda, potash and manganese, to the last of which it probably owes its colouring.

Indian manganese-ores.

Of the manganese-minerals given in the list on page 75 there are nine (marked with an asterisk) with which every manganese-miner in India should be familiar, and consequently short notes on them are given below.[2] Of these the first six are usually regarded as ores.

---

[1] *Amer. Jour. Sci.*, XLVI, 3rd series, p. 292, (1893).

[2] Some of the data given are based on the writer's observations and some are taken from Dana's *System of Mineralogy.*

Braunite ($3Mn_2O_3.MnSiO_3$)—sesquioxide of manganese in combination with manganese-silicate. Theoretical maximum % of Mn = 63·59. Hardness (H) = 6 to 7; hence it cannot be scratched with a knife. Specific gravity (G) = 4·75 to 4·82. It crystallizes in the tetragonal system as octahedra, but is usually found massive in India, often showing brilliant shining facets due to its perfect octahedral cleavage. In colour braunite is dark steel-grey to black, with a metallic lustre and blackish streak. Small chips are slightly magnetic. It is the ore, *par excellence*, of the Central Provinces and to a less extent of Jhábua and Vizagapatam.

Pyrolusite (MnO_2)—peroxide of manganese. Theoretical maximum % of Mn = 63·22. It is very soft, soiling the fingers, and is black to bluish-grey or steel-grey in colour; it is often crystalline with a bright metallic lustre and tends to form radiate-concentric masses. G = 4·73 to 4·86. Very handsome specimens are found at Páli, Nágpur district, in cavities in the crystalline limestone. It is also found commonly in the Jabalpur and Vizagapatam districts.

Manganite ($Mn_2O_3.H_2O$)—hydrated sesquioxide of manganese. Theoretical maximum % of Mn = 62·50. H = 4; hence can be scratched by knife. G = 4·2 to 4·4. It crystallizes in orthorhombic prisms sometimes elongated to needle-like crystals as in the only undoubted occurrence of this mineral in India, namely a nodule obtained from the Sandur Hills, Madras.[1] Colour, dark steel-grey to iron-black, sometimes with a bronze-like tarnish. Streak, reddish-brown to black.

Psilomelane—a complicated hydrous manganate of manganese and other bases such as barium and iron. On the assumption that this mineral forms with hollandite a group of man-

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 229–232, (1906).

ganates, the theoretically highest possible °/₀ of Mn will be 67·35 corresponding to the formula Mn_2MnO_5. H = 5 to 6; hence it can sometimes be scratched, though with difficulty, by a knife, and sometimes not at all. G = 3·7 to 4·7. It is an iron-black to blue- or steel-grey mineral occurring both massive and in botryoidal and stalactitic shapes, and usually having a rather dull lustre. It is the most widely spread of all the Indian manganese-ores, and with braunite forms the large bulk of the manganese-ore exported from India.

Wad is a soft, light, porous variety of psilomelane found abundantly in some of the Vizagapatam mines; the Indian wad is not, however, turned to any account.

Rhodochrosite or *dialogite* ($MnCO_3$)—manganese carbonate. Theoretical maximum °/₀ of Mn = 47·83. It is white, pink or light brown in colour, with a rather pearly lustre, and is easily scratched by a knife (H = 3·5 to 4·5), while it effervesces briskly with warm dilute hydrochloric acid (and is thus distinguished from rhodonite, which it somewhat resembles). G = 3·45 and over. This mineral has only been found at two localities in India, namely Gaimukh and Devi in the Chhindwára district, C.P., and there only in small quantities.[1]

Character and quality of the ores.

The manganese-ore being despatched from the Central Provinces consists very largely of an intimate mixture in varying proportions of braunite and psilomelane. This ore is of fine grain, usually very hard and tough, and little crystalline facets of braunite may often be distinguished in the psilomelane-braunite groundmass. These braunite crystals may increase in size and abundance until almost the whole specimen is coarsely crystalline braunite, as at Thirori, Bálághát district. In other cases the ore may be entirely psilomelane, as at Bálághát itself.

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp 211, 212, (1906).

At one locality only—Páli, Nágpur district—has any attempt been made to quarry pyrolusite. In the Vizagapatam district, Madras, on the other hand, the common ore is psilomelane sometimes containing an admixture of more or less braunite, which then appears as little scattered specks, though occasionally found massive. From some of the deposits, abundance of pyrolusite is also obtained. The mineral constitution of the ores from the Kájlidongri mine, Jhábua State, Central India, has not yet been decided, but they have the usual fine-grained appearance, dark-grey colour, and hard, compact character of the ores from the Central Provinces and probably also consist of a braunite-psilomelane mixture.

The range in quality, as shown by analysis, of the ores shipped from the three producing provinces, is given in the following table :—

Table 2.

Average analysis of Manganese-ores exported from the three producing provinces.

	Central India.	Central Provinces.	Madras.
Railway lead in miles to shipping port.	361	500–700	56
	Per cent.	*Per cent.*	*Per cent.*
Manganese ...	46–48	50–55	43–50
Iron	8–9	5–8	5–13
Silica	6–9	5–9	2–6
Phosphorus ...	0·08–0·25	0·05–0·12	0·15–0·60
Moisture	below 0·25	usually below 1·0	05·–2·0

Important associated manganese-silicates.

The three other minerals which have been asterisked are manganese-bearing silicates which, although of no commercial value as long as large quantities of oxide-ores are found in various parts of the world, are so frequently found in association with the economically valuable ores that they require a brief description.

Rhodonite ($MnSiO_3$)—metasilicate of manganese. Theoretical maximum °/₀ of Mn = 41·86. H = 5·5 to 6·5 : *i.e.*, it is not scratched by a knife. G = 3·4 to 3·68. It is a triclinic pyroxene found under the same circumstances as spessartite (see below), with which it often forms a spessartite-rhodonite-rock with or without quartz. The rhodonite is almost invariably rose-pink (but occasionally greenish-grey), and when orange spessartite is scattered through rose rhodonite, a very beautiful rock is the result. The rhodonite always forms a granular to coarsely crystalline rock, never occurring as crystals with measurable faces. Further, the rhodonite-bearing rocks are often quite black outside, due to oxy-alteration, and the pink colour is only seen on breaking the rock. Rhodonite has been found in the following districts and states :—

Nárukot, Bombay ;
Jhábua, Central India ;
Chhindwára and Nágpur, Central Provinces ;
Ganjám and Vizagapatam, Madras.

Spessartite or *manganese-garnet* ($3MnO.Al_2O_3.3SiO_2$) —orthosilicate of manganese and alumina. Theoretical maximum °/₀ of Mn = 33·24 ; but the actual °/₀ of Mn is usually considerably below this figure owing to an isomorphous replacement of manganese by iron and calcium and of alumina

by iron. H = about 7; hence it cannot be scratched by a knife. G = 4·0 to 4·3. Spessartite is the commonest of the Indian manganese-silicates and is an almost invariable associate of the workable deposits of manganese-ore. When well crystallized, as at Chárgáon near Rámtek, Nágpur district, the crystal habit is seen to be trapezohedral.

Fig. 1 represents a very fine trapezohedron of spessartite obtained at Chárgáon, Nágpur district. It is complete in all its twenty-four faces which are beautifully striated parallel to those of the rhomb-dodecahedron.

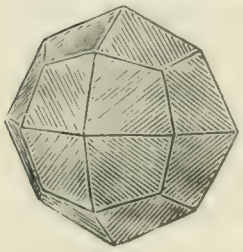

Fig. 1
Crystal of Spessartite. Nearly twice natural size.

In Fig. 2 is shown a very fine crystallization of the same mineral. When the crystals are not too large, spessartite varies in colour from bright yellow through orange and orange-brown to deep orange-red; but the larger crystals, owing to the density of the colour, often appear dark-brown or even black, as in the specimen shown in Fig. 2; their true colour, however, is seen when they are broken into smaller pieces. The mineral being very prone to alteration is also often blackened owing to the formation of manganese-oxides. One of its commonest modes of occurrence is as a fine-grained very tough spessartite-quartz-rock of cinnamon to yellow or yellow-grey colour. Spessartite has been found in the following districts and states:—

Nárukot, Bombay;

Jhábua, Central India;

Bhandára, Bálághát, Chhindwára and Nágpur, Central Provinces;

Ganjám and Vizagapatam, Madras.

Photo by H. B. W. Garrick.

FIG. 2- **Spessartite crystals (trapezohedra) with interstitial quartz, on a basis of manganese-ore. From Warega'on, Nágpur district. Natural size.**

Piedmontite or *Manganese-epidote* [$Ca_2(Al.OH)(Al,Mn,Fe)_2(SiO_4)_3$]—a complex orthosilicate of calcium, aluminium, manganese and iron. It contains only 3·5 to 10·5 per cent. Mn. H = 6·5. G = 3·40. It usually occurs in association with crystalline limestones which then often contain bands of nodules of manganese-ore. This is a mode of occurrence of manganese at present of no proved economic value, though some attempt has been made to work residual accumulations of these nodules formed by solution and removal of the limestone matrix, as at Junawáni, Nágpur district. The piedmontite occurs in deep purplish crimson grains, and in satiny-looking nodules of the same colour, in the limestone. This mode of occurrence has only been noticed in the Nágpur district; piedmontite also occurs at the Kájlidongri mine, Jhábua State, and near Jámbughoda, Nárukot State.

2.—Origin and Mode of Occurrence of the Indian Manganese-ore Deposits.[1]

Classification. The manganese-ore deposits of India can be classified as follows :—

A. Braunite, psilomelane and pyrolusite associated with, and derived from, manganese-bearing silicates (such as spessartite, rhodonite and less frequently piedmontite) occurring as bands and lenticles in the Archæan schists and gneisses. Examples of these occur in—

(1) Nárukot in Bombay;
(2) Jhábua in Central India;
(3) *Bálághát, Bhandára, Chhindwára and Nágpur* in the Central Provinces;
(4) Ganjám and *Vizagapatam* in Madras.

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 94–100, (1906).

B. Psilomelane and pyrolusite superficially formed on the outcrops of rocks of Dhárwár age—

(1) Singhbhum in Bengal;
(2) Dhárwár, and Panch Maháls in Bombay;
(3) Jabalpur in the Central Provinces;
(4) *Sandur Hills* in Madras.

C. Psilomelane and pyrolusite associated with, or contained in, laterite. Localities:—

(1) Belgaum and Sátára in Bombay;
(2) Jabalpur in the Central Provinces.

The localities in italics are those in which economically important deposits have been located and in most cases worked. Belgaum may possibly be added to these in the future. It will be seen that from every point of view, economic, mineralogical and petrological, the chief interest centres in the deposits of Group A.

Manganese-ores have also been found in many other parts of the Indian Empire but not in sufficient quantity to merit notice in this paper.

Group A.

As the result of a careful examination of some of the manganese-ore deposits of the Vizagapatam district and especially of the Kodur mines, where the quarrying has now been in progress for over 13 years, it has been found possible to formulate a definite theory as to the origin of the manganese-silicate rocks from which the manganese-ores are regarded as having been derived, at least in part, by chemical alteration, and this theory can be applied in a more or less modified form to the rocks of similar nature occurring in the Archæan complex of other parts of India.

The Vizagapatam district, geologically speaking,

consists of a complex of Archæan rocks which has been separated into three groups—(1) the Khondalite series, (2) the Charnockite series, and (3) the Gneissose granite. The manganese-ore bodies have been found only in close relationship with (1) and (3), and, briefly stated, the conclusions as to their origin are as follows :—

Vizagapatam district, Madras.

(*a*) Rocks containing a large proportion of manganese-silicates, such as spessartite[1] and manganese-pyroxenes, and of which the most general and characteristic type is apatite-spessartite-felspar-rock, have been intruded in Archæan times as part of an igneous magma into the rocks of the Khondalite series.

(*b*) Under the influence of chemical waters, doubtless heated, the manganese-silicates have been decomposed, and the manganese has been removed from some parts of the rock-mass and re-deposited in the form of oxides in other parts, and so added to the manganese already there, replacing at the same time any felspar not already decomposed and removed.

This theory can be stated in more precise detail, in a form especially exemplified by the Kodur and Garbhám mines, as follows :—

(*a*) The original magma had a composition corresponding to a mixture of apatite, felspar, quartz, spessartite and various manganese-pyroxenes.

(*b*) This magma while still molten became differentiated into various units.

(*c*) The magma was then erupted and intruded, probably into the rocks of the Khondalite series; on solidifying, the following rocks among others crystallized out :—

[1] An analysis recently made by Mr. J. C. Brown, Geological Survey of India, of the manganese-garnet of Kodur has shown that it is intermediate in composition between spessartite and andradite.—June 24th, 1906.

(1) Felspar-rock,
(2) Felspar-quartz-rock,
(3) Spessartite-felspar-rock,
(4) Spessartite-pyroxene-felspar-rock,
(5) Spessartite-pyroxene-rock,
(6) Spessartite-rock,
(7) Apatite-spessartite-felspar-rock.

(*d*) The more basic manganiferous rocks 3 to 7 were probably distributed as streaks and patches in the more acid rocks 1 & 2.

(*e*) Hot mineral waters then attacked these manganiferous rocks, probably at once, but at any rate in Archæan times, and as the result of this action manganese-ores were formed in two ways. In many cases manganese was taken into solution and carried to another part of the rock-mass where it was deposited so as to replace all the minerals of the rock, except those containing manganese, which in some cases remained fresh and unaltered and in others were also broken up. (See Fig. 16.) Thus the manganese-ore, resulting from the replacement of rock No. 7, sometimes consists of compact psilomelane studded with bright-red or orange spessartite-garnets, and at other times entirely of manganese-ore. In the case of most of the spessartite-rock, however, the lime, alumina and silica were carried away, leaving a porous mass of iron and manganese oxides which was more or less consolidated by the introduction of more manganese-oxide from other parts of the deposit.

(*f*) Another result of the series of chemical changes taking place has been the conversion into kaolin and lithomarge of almost all the felspar; and, as a further consequence of the removal of material from one part of the rock-mass to another, there has been a frequent adjustment of equilibrium producing small slips and folds.

Such an explanation as the above satisfies all the requirements of the majority of the Vizagapatam deposits and accounts well for the extraordinary jumble of rocks seen at Kodur.

The accompanying map (Fig. 3) is a rough geological sketch-map of the Kodur mines area. The structure of the ground along the line XY, may either be interpreted as in Fig. 4, on which supposition the manganese-intrusives have found their way along the divisional planes of the scapolitic gneisses regarded as forming a part of the Khondalite series ; or the repetition of the same rocks on each side of the

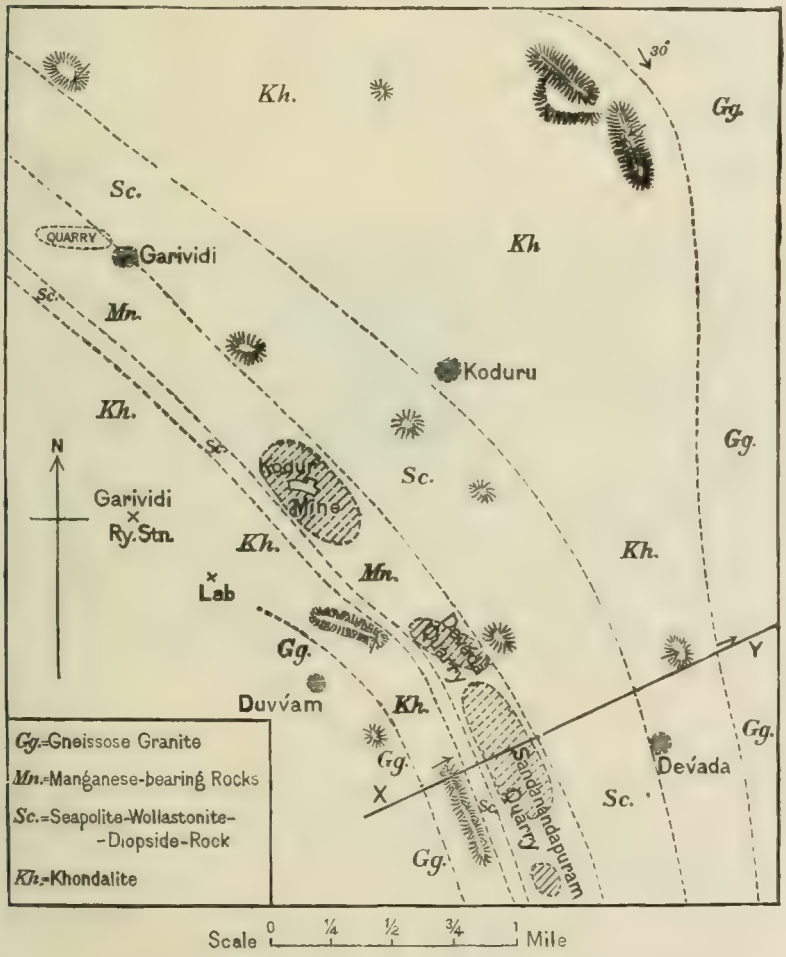

FIG. 3.—**Geological Sketch Map of the Kodur Mines, Vizagapatam district.**

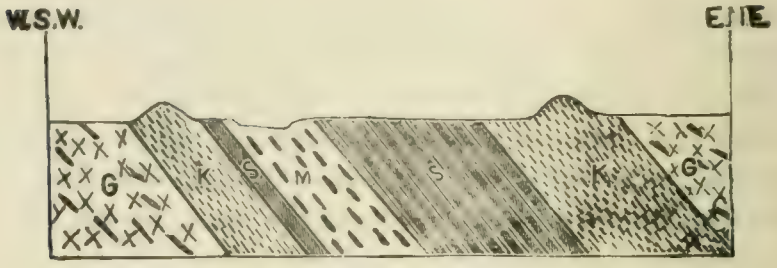

Fig. 4.

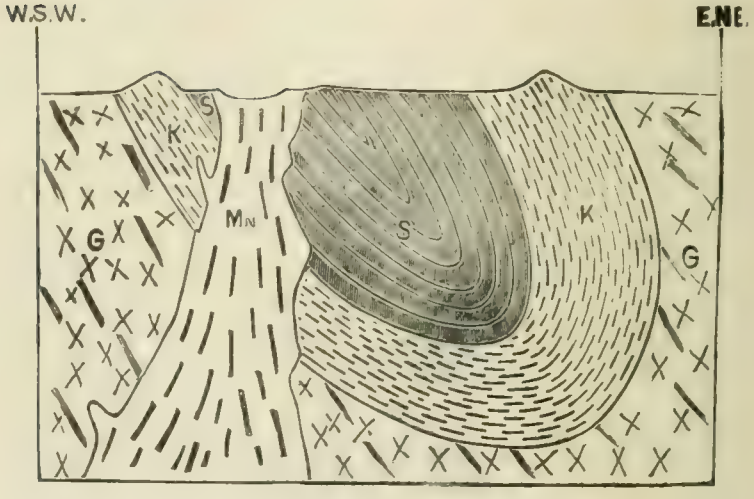

Fig. 5.

G = Gneissose granite ; K = Khondalite ;
S = Scapolite-wollastonite-diopside-gneiss ;
Mn = Manganese-instrusives.

Scale :— 0 $\frac{1}{4}$ $\frac{1}{2}$ $\frac{3}{4}$ 1 mile.

Heights of hills exaggerated.

Figs. 4 and 5.—**Alternative interpretations of structure along the line of section XY, in Fig. 3.**

ore-band may indicate an overturned synclinal through which the manganiferous intrusives have burst as indicated in Fig. 5. The latter interpretation is perhaps the more likely. Three isolated masses of crystalline limestone found in the midst of manganiferous intrusives in the Kodur mine are to be regarded as xenoliths torn up from below at the time of injection of these intrusives and probably further metamorphosed in the process.

Ganjám district, Madras.

The few occurrences of manganese-ore investigated in the Ganjám district are of no economic value, but are interesting because they are associated in one case with spessartite-felspar-rock and, in another, with apatite-spessartite-rhodonite-rock.

The Nágpur-Bálághát area, Central Provinces.

In the Nágpur-Bálághát area, comprising the districts of Bhandára, Bálághát, Chhindwára and Nágpur, the manganese-ore occurs as lenticular bands and masses, intercalated parallel to the strike, in the quartzites, schists and gneisses. The ore is frequently found to pass both laterally and along the strike into partly altered or quite fresh spessartite-quartz-rock, or rhodonite-spessartite-quartz-rock. The typical rock from which these manganese-ore deposits have been, at least in part, derived, is this spessartite-quartz-rock, often containing a small quantity of apatite, and usually quite free from felspar.

Theory as to Origin.

Although the evidence is not so conclusive as in the Vizagapatam district, yet it seems probable that here also the original manganese-bearing rock was intruded in the molten condition into the metamorphic schists and gneisses. But in this case it is probable that the rocks have often been subjected to intense folding subsequent to the alteration of manganese-silicate to manganese-ore. The effect of this folding has been twofold :—

(1) To squeeze or roll out the manganese-intrusives so that almost all the bands of manganiferous rock now conform to the strike of the enclosing metamorphic schists and gneisses; the only clear exception yet found is the Rámdongri ore-body, the boundaries of which are often transgressive with regard to the associated schists and quartzites.

(2) The manganese-ores, which were perhaps once cavernous, porous and friable, like those of the present day in the Vizagapatam district, have been compressed into a very compact, hard, more or less crystalline form.

The last paragraph indicates the probable reason for the superior physical character of the Nágpur ores over those of Vizagapatam, while their less phosphoric character (see page 82), is due, of course, to the spessartite-quartz-rock of the Nágpur area, containing less apatite than the apatite-spessartite-felspar-rock of Vizagapatam.

Dimensions of Ore-bodies.

The ore-bodies often attain great dimensions, and their disposition as irregular lenses along the strike of the enclosing schists naturally influences the miner in laying out the boundaries of his "claims." A deposit near Bálághát is $1\frac{3}{4}$ miles long; at Mánegáon in the Nágpur district the ore-body is $1\frac{1}{2}$ miles long; whilst at Thirori, in the Bálághát district, it is nearly 6 miles in length. As examples of great breadth, may be quoted Kándri, 100 feet thick, of pure ore; and Rámdongri, 1,500 feet of ore and unaltered spessartite-rock. The depth of these ore-bodies is quite unknown, as the so-called mining has so far passed little beyond the quarrying stage.

The question has been frequently asked as to what term

should be applied to describe the form of the manganese-ore deposits, especially those of the Central Provinces; *i.e.*, should they be called veins, reefs, beds, or anything else? *Vein* is most emphatically the wrong term to apply, while *reef*, although a somewhat looser term, is hardly a suitable one. The ore-bodies often take the form of bands having a fairly constant width over a considerable distance; the divisional planes which are often found parallel to the length of the deposit then frequently impart to it a well-bedded appearance. If it be wished to apply the term *bed* to such an ore-body, it must be with the understanding that the so-called 'bed' does not necessarily extend continuously in depth or along the strike over a large area, as it would in the case of a bed of sandstone or a coal-seam (faults being supposed absent), but that it probably dies out in lenticular fashion within quite a moderate distance. The Kájlidongri deposit is a good example of one with regard to which it seems difficult to object to the term 'bed,' since the ore-bands are intercalated, and folded up, with quartzites so as to exactly resemble a bed. There is no doubt, however, that the most suitable terms are *ore-lentick* when the ore-body has a decidedly lenticular shape, or *ore-band* when it takes the form of a band extending over a considerable distance. When, however, there is any doubt—as there almost always is—about the shape of the mass of ore, it should be designated by the term, already used several times in this paragraph, *ore-body*. This term is always applicable provided it be confined to the original mass of ore *in situ* and not applied to the talus- or pebble-ore derived from it.

Form of the Ore-bodies.

For other modes of occurrence of manganese-ores in the Nágpur area, see under pyrolusite (page 80) and piedmontite (page 85).

Jhábua State, Central India.

The manganese-ore deposit at Kájlidongri near Meghnagar railway station consists of much folded alternating quartzite and manganese-ore layers, associated with spessartite- and rhodonite-bearing rocks; it is to be classed with the deposits of the Central Provinces rather than those of Vizagapatam. This deposit is one of the most interesting in India on account of the varieties of minerals it has yielded. These include winchite, a pyroxene allied to blanfordite, and hollandite, (see list, page 75), all new species, piedmontite and carpholite (?).

Narukot State, Bombay.

Near Jothvád, about two miles north of Jámbughoda, in the Nárukot State, is a small hill of contorted gneisses which include many bands of manganiferous rocks containing, amongst other minerals, spessartite, rhodonite and piedmontite with very abundant apatite. This hillock is surrounded by porphyritic biotite-granite, which has invaded the gneisses and enclosed in itself portions both of these and of the manganiferous rocks, the latter being in some cases partially converted into manganese-ore. The granite is similar to that of Bundelkhand, and of other areas where there is little doubt of its Archæan age. It seems likely, therefore, from this occurrence, that the development of manganese-ore from the manganiferous silicates took place in Archæan times.

List of the Group A. deposits.

For future reference, I have given below a list of all the manganese-ore deposits of Group A., which were visited by myself or with regard to which I have been able to obtain definite information. At those localities in italics quarrying work of some importance, usually resulting in export, has been carried on.

BOMBAY—

Nárukot State.

1. Jothvád.

CENTRAL INDIA—

Jhábua State.

1. *Kájlidongri.*
2. Rambhápur.

CENTRAL PROVINCES—

Bálághát District.

1. Chándadoh.
2. *Thirori*, Ponia and Jamrapáni.
3. Sonegáon.
4. Arjoni and Jám.
5. Nándgáon.
6. Ramrama.
7. Katangjheri I (Government Forest).
8. Katangjheri II (Málguzári.)
9. *Bálághát.*
10. Ghondi.
11. *Ukua.*

Bhandára District.

1. Kosumbah.
2. Sitapathur.
3. Sukli.
4. Hatora.
5. *Miragpur.*
6. Mohugáon Ghát.
7. Pándarwáni.
8. Sálebaddi.
9. Chikhla II.
10. *Kurmura.*
11. *Chikhla I.*
12. Sitasáongi.
13. Ásalpáni.
14. *Pachára.*

Chhindwára District.

1. Kachi Dhána.
2. Lakhanwára.
3. Gaimukh.
4. Sitapár.
5. Bichua.
6. Alesur.
7. Devi.
8. Ghoti.
9. Wagora.
10. Gowári Warhona.
11. Dudhára.

Nágpur District.

1. *Kodegáon.*
2. *Gumgáon.*
3. *Rámdongri.*
4. Risára (Reechara).
5. Nándgondi.
6. Sitagondi.
7. *Kándri.*
8. *Mansar.*
9. *Mansar Extension.*
10. *Parsoda.*
11. Borda.
12. Pársioni and Bansinghi.
13. Dumri Kalán.
14. *Sátak.*
15. *Beldongri.*
16. Nagardhan.
17. *Nandapuri.*
18. *Lohdongri.*
19. *Kácharwáhi.*
20. *Waregáon.*
21. Khandála.

22. *Mándri.*
23. *Máncgáon.*
24. *Guguldoho.*
25. Bhandárbori.
26. Mohugáon.
27. *Páli.*
28. Ghogara (Pench River)
29. *Mándvi Bir.*
30. *Junawáni.*
31. Junapáni.

MADRAS—

Ganjám District.

1. Boiráni.
2. Nautan-Barampur.

Vizagapatam District.

1. *Garividi.*
2. *Kodur.*
3. *Duvvám.*
4. *Devádа.*
5. *Sandananda-puram.*

The Kodur Mines.

6. Sivarám.
7. *Perapi.*
8. Itakerlapilli.
9. Mulagám.
10. Govindapuram.
11. *Garbhám.*
12. *Kotakarra.*
13. Gadasám.
14. *Avagudem.*
15. *Aitemvalsa.*
16. *Gotnandi.*
17. *Bondapilli.*
18. *Garrarája Chipurupalli* (Garuja).
19. *Perumáli.*
20. *Rámabhadrapuram.*
21. Táduru.
22. Chintelavalsa.
23. Thonaum.

Comparison with the Brazilian deposits.

Before leaving this section of the paper it will be interesting to compare the Indian manganese-ore deposits of Group A with those of the Queluz district, State of Minas Geraes, Brazil, the only ones, as far as the writer can discover, which bear any resemblance to those of India. Orville A. Derby,[1] who has studied the Brazilian deposits, ascribes their formation in many cases to the decomposition and leaching of basic manganiferous rocks of which the most important mineral is manganese-garnet (spessartite). These masses of manganiferous rock often occur as dyke-like masses and are considered to be the result of magmatic segregation from a basic

[1] *Amer. Journ. Sci.*, XII, pp. 18-32, (1901).

magma of dioritic, gabbroitic or noritic type, now represented by the very decomposed, and sometimes sheared, clay-like country in which the manganese-ore bodies occur.

It will be seen that there is a general analogy between this theory and that which is supposed to explain the formation and structure of the Vizagapatam deposits of India. The analogy, however, only applies to the processes, *i.e.*, the magmatic segregation of the manganiferous rocks from a molten magma, with subsequent chemical changes producing the ore-bodies from the manganiferous rocks and the clays (or lithomarges) from the less manganiferous country-rock—and not to the actual rocks concerned. For in Brazil the residual rock, left after the segregation from the magma of the manganiferous rocks, was of basic character, while in Vizagapatam it was either a felspar- or felspar-quartz-rock, *i.e.*, a more acid rock. The product of segregation in Brazil, moreover, was essentially a manganese-garnet rock sometimes containing an amphibolic (or perhaps pyroxenic) or micaceous mineral, and at other times instead of these latter free (original) manganese-oxide (? polianite) with ilmenite and rutile as accessories and a very small quantity of apatite, while both quartz and graphite, supposed to be subsequent introductions, also occur.[1] As shown on page 88, the typical product of segregation in the Vizagapatam area is a considerably different rock of which the three chief constituents, apatite, spessartite, and felspar, are all equally important.

GROUP B.

Singhbhum district, Bengal.

The manganese-, and manganiferous iron-ores of Singhbhum, first noticed by V. Ball,[2] are very similar to those of Jabalpur. They

[1] This type of rock has been denominated *queluzite* by Derby, *loc. cit.*, p. 30.

[2] *Mem. Geol. Surv. Ind.*, XVIII, p. 147, (1881).

consist chiefly of psilomelane formed by the superficial replacement of sericite-phyllites, quartzites and felspathic grits which may be doubtfully referred to the Dhárwár system. They are found in the area immediately south of Cháibása and only occur in small quantities very irregularly distributed.

Dhárwár district, Bombay.

As the chief locality for manganese-ore in the Dhárwár district may be mentioned Chik-Vadvati, Kappatguda Hills, Sangli State, long ago visited by Newbold [1] and recently examined by Mr. J. M. Maclaren, who found that the manganese-ores, chiefly psilomelane, of this district, occur on the outcrops of banded, limonitic, jaspery quartzites of Dhárwár age, and his specimens show that they must have had an origin precisely similar to those of the Jabalpur district. They likewise are of no economic value.

Panch Máháls district, Bombay.

The manganese-ores of the Panch Maháls district, Bombay Presidency, consist of psilomelane and pyrolusite, and have been formed by the superficial replacement of slates and quarztites of the Chámpáner series, which is probably the same as the Dhárwárs. The best locality is Sivarájpur, first noticed by the late Dr. W. T. Blanford.[2] The economic value of these deposits is doubtful.[3]

Jabalpur district, Central Provinces.

The manganese-ores of this district occur in the vicinity of Gosalpur and Sihora in a belt of Dhárwár rocks which stretches for 20 miles in a N.E.–S.W. direction with a maximum width of 7 miles. These rocks are chiefly quartzites, shales, slates, and hematite-schists banded with jaspery quartzite.

[1] *Journ. Roy As. Soc.*, VII, p. 212, (1843).

[2] *Mem. Geol. Surv. Ind.*, VI, p. 341, (1869).

[3] Manganese-ore is said to have been recently quarried and despatched to Europe from this locality.

The manganese-ores can be divided into two classes :—

1. Manganiferous iron-ore and psilomelane.
2. Pyrolusite.

The banded jasper-hematites have often been converted at the outcrop into large masses of manganiferous limonite forming caps to the ridges in which these rocks occur. This manganiferous limonite is simply limonite veined with psilomelane, which in places forms large segregations. In other cases the hematite-schists have, by the development of little veins of manganese-ore, been converted at the outcrop into manganiferous hematite. The manganese has, in both cases, been no doubt derived from the small percentage of this element contained in the hematite ; in some cases this concentration of manganese has proceeded to such an extent that considerable quantities of nodular psilomelane have collected on the hematite outcrops. At the same time, the accompanying jasper, slate, and sericite-phyllites have often been converted into manganese-ore by replacement. The pyrolusite usually occurs as nests and strings in the Gosalpur quartzites of Mr. P. N. Bose[1] and as nodular segregations in the laterite débris often covering these rocks. It, also, has no doubt been derived from the hematite-schists.

Sandur Hills, Madras.

Manganese-ores were first noticed in this area by Newbold, and their occurrence has been described by R. B. Foote.[2] A large ore-body has been recently located at Rámandrug and is now being worked for export. The ore is mainly psilomelane. Mr. C. Aubert has given me the following figures as showing the range in composition of the ores as determined by the analysis of small specimens :—

[1] *Rec. Geol. Surv. Ind.*, XXII, p. 218, (1889) ; see also *ibid.*, XXI, pp. 71-88, (1888).

[2] *Mem. Geol Surv. Ind.*, XXV, pp. 194-196, (1895).

		Per cent.		
Manganese	...	39	to	54
Iron ...	...	19	to	5
Silica ...	...	1·0	to	0·43
Phosphorus	...	0·016	to	0·033

Group C.

Belgaum district, Bombay.

Mr. J. M. Maclaren in 1905 paid a brief visit to the manganese-ore deposit at Talevadi, then being developed by Messrs. Jambon & Cie. He found the manganese-ore to occur as more or less spherical concretions in a deposit of laterite 15 to 20 feet thick; they exhibited in the pits sunk a gradual passage downwards into quartz-schist; this in its turn rests on a slightly manganiferous limestone, which, like the quartz-schist, is of Dhárwár age.

Sátára district, Bombay.

The manganese-ores of the Mahábaleshvar and Yeruli plateaux in the Sátára district occur as concretions of psilomelane in a small thickness of lateritic soil, resting on the Deccan Trap. They never occur in sufficient quantity to pay for extraction, and have probably been formed by concentration of the manganese which all such basic lavas must contain.

Jabalpur district, C.P.

The lateritic manganese-ore of the Jabalpur district is so insignificant in quantity that it is sufficient to refer to page 99 above and to *Records, Geol. Surv. Ind.*, XII, p. 99, (1879).

III.—MINING AND ECONOMICS.

1.—History of the Manganese Mining Industry in India.

In spite of the large number of localities for ores of manganese enumerated in Ball's Economic Geology of India, published in 1881, it was not until the early nineties that Indian

geologists and miners began to realize the possibilities of India with regard to this mineral. The manganese mining, or rather quarrying, industry had its commencement in 1892 in the Vizagapatam district, Madras Presidency, and the output from this area has constantly increased from 3,130 tons in 1893 to a maximum of 92,458 tons in 1900, since when there has been a gradual decline in output due to some of the deposits having been worked down to a level—only 50 to 100 feet—at which so much water enters the pits that the difficulty of winning the ore has become much increased. The output for 1905 from the mines of this district was 63,669 tons. In 1899 attention was directed to the Nágpur district, Central Provinces, and an initial production of 35,356 tons in 1900 was the result. The industry in this region has, with the exception of a slight check in 1904, due to the low price per unit of manganese, constantly expanded with the discovery and development of many fresh deposits in the Nágpur, Bhandára and Bálághát districts, so that the output for 1905 has reached the unprecedented total of 153,494 tons. Active work is also proceeding at a single deposit in the Jhábua State, Central India Agency. A start was made in 1903 with an output of 6,800 tons, which rose to 30,251 tons in 1905. The past year also saw the start of the development of a deposit in the Sandur Hills. It is probable that, within the next two or three years, the Chhindwára district, Central Provinces, will be added to the list of producers.[1]

Output.

The following table shows the output in long tons of manganese-ore from each of the producing provinces since the beginning of the industry :—

[1] Since this paper was read news has been received of the export of manganese-ore from the Shimoga district, Mysore, and the Panch Mahâls district, Bombay.—June 24th, 1905.

TABLE 3.

Production of Manganese-ore from 1893 to 1905.

	Central India.	Central Provinces.	Madras.	Total.
1893			3,130	3,130
1894			11,410	11,410
1895	...		15,816	15,816
1896	... .	.	56,869	56,869
1897			73,680	73,680
1898	.....	.....	60,449	60,449
1899	...		87,126	87,126
1900	.....	35,356	92,458	127,814
1901	... ..	44,428	76,463	120,891
1902	.....	89,609	68,171	157,780
1903	6,800	101,554	63,452	171,806
1904	11,564	85,034	53,699	150,297
1905	30,251	153,494	63,669	247,462*

* This includes 48 tons raised in the Belgaum district and is only to be regarded as a provisional total. The figures for the C.P. are probably too low.—June 24th, 1905.

Photo by L. L. Fermor

FIG. 7.—Quarrying Manganese-ore at Kájlidongri.—Jhábua State, C.I.

Photo by L. L. Fermor.

FIG. 8.—Outcrop of Manganese-ore on top of Mansar Hill.—Nagpur District, C.P.

The following diagram expresses these figures graphically :—

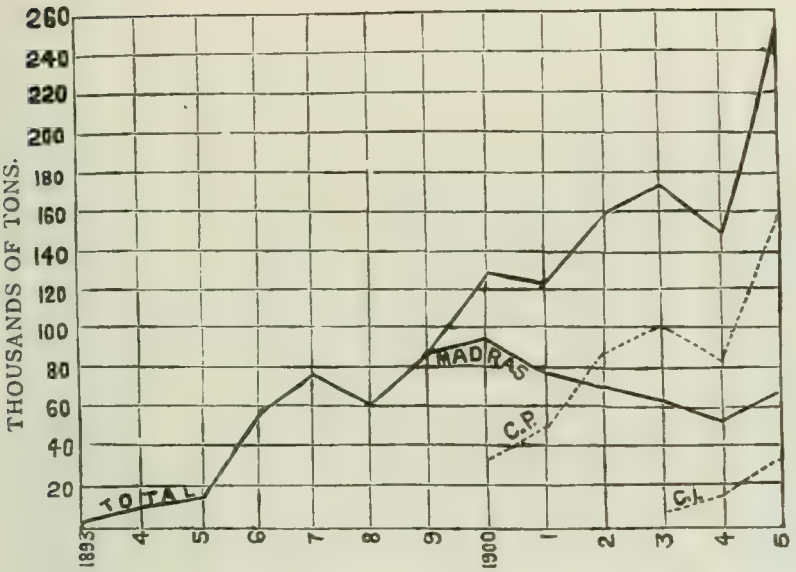

Fig. 6.—**Diagram shewing production of Manganese-ore in India since the commencement in 1893.**

Thus it will be seen that, taking India as a whole, there is a general tendency for a steady and constant increase in output. But as the rate of increase naturally depends to a large extent on the prices prevailing from year to year, it is necessary to compare the fluctuations in the price per unit of manganese with those of the output.

Prices.

Table No. 7 (page 113) and the diagram, Fig. 17, (page 115) show the half-yearly prices per unit of manganese c.i.f. at United Kingdom ports from January 1890 to the present date. Considering only first-grade ore, it will be seen that the Vizagapatam deposits began to export in 1893 when the price was 14 to 15 pence and that those of the Central Provinces came on to the market in 1900 with the price ranging from 13 to 15 pence. In the next four years the production of manganese-ore so increased in various parts of the world that the price gradually fell until 1904 and the beginning of 1905 when it reached its minimum of $8\frac{1}{2}$ to $9\frac{1}{2}$ pence. It was then that many of the deposits in the Central Provinces were closed down, thus accounting for the production of manganese-ore during 1904 being somewhat below that of 1902 and 1903.

During 1905, owing to the disturbances in the Caucasus, the export of manganese-ore from that region was stopped, while there was an improvement in the conditions of the iron and steel industry in the United States. The result has been that steel-makers in Europe and America have been unable to obtain sufficient manganese-ore to meet their requirements. The price has consequently risen by leaps and bounds so that it is said to have recently touched eighteen pence, just double what it was a little over a year ago. The result has been the unprecedented exports in 1905 of India and Brazil, the two most important manganese-ore producing countries after Russia. Throughout India there might be said to exist at present a sort of manganese fever which is leading both to very active prospecting for new deposits, and to the feverish working of the already known deposits with sometimes, it is to be feared, detrimental results to their future prospects, so that it will possibly be found imprac-

Photo by L. L. Fermor

FIG. 9.—**Manganese-ore Quarry at Kodegaon.—Nagpur District, C.P.**

This has been excavated on a body of manganese-ore, the top of which was just exposed at the surface of an alluvial field. (A) is this original outcrop. On the further side of the quarry a loose pebble-bed of ore (B), covered with alluvial clay (C), is seen resting on the manganese-ore (D) *in situ*. All the rock visible in the quarry is manganese-ore *in situ*. (E) consists of stacked ore ready for carting. (1-11-03.)

Photo by L. L. Fermor

FIG. 10.—**General view of the Manganese-Quarry at Ka'ndri.—Nagpur District, C.P.**

It shows the well-defined ore-body (O) running across the centre of the plate from the base to the summit of the hill (250 feet high). The ore-body is being attacked by means of the four levels, 1, 2, 3 and 4, approaching it from the right-hand side. The embankments formed of the waste material are seen running away to the right from the working faces in O. A is the upper trestle of the aerial ropeway in use at the time of my visit (18-1-04), and B is the first trestle of a new ropeway since completed. D = stacks of ore ready for carting. F = an inclined way since completed. At G are shown workings in the talus-ore derived from the ore-body.

ticable, when the next drop in prices comes, to work certain deposits which, if rationally treated, would yield a constant supply of ore.

Comparison with foreign production.

To understand the prominent position which India has now taken amongst the manganese-ore producing countries of the world, it is only necessary to refer to the following table showing the last reported production or exports of the principal producers.

TABLE 4.

Principal sources of Manganese-ore, and latest reported productions.

Country.	Year.	Production.	Country.	Year.	Production.
Russia (Exports) [1] ...	1905	388,231	France [4] ...	1903	11,417
Brazil (Exports) [1] ...	1905	262,416	Austria [3] ...	1904	10,189 (*m*)
India [2] ...	1905	247,462	Turkey (Exports) [1] ...	1905	8,164
Cuba [3] ...	1904	33,152 (*m*)	Chili (Exports) [1] ...	1904	6,337
Spain (Exports) [1] ...	1905	30,507	Greece (Exports) [1] ...	1905	4,645
United Kingdom [6] ...	1905	14,352	Japan (Exports) [1] ...	1905	3,944
Hungary [4] ...	1903	12,490 (*m*)	Borneo [5]	...	...

Manganiferous iron-ore is produced in important quantity by the four countries shown in table 5.

[1] Figures compiled and kindly supplied by Messrs. Macqueen Bros., London.

[2] From figures obtained from various sources. Probably an under-estimate.

[3] "The Mineral Industry," 1904.

[4] "The Production of Manganese Ores in 1904," by J. Birkinbine, U.S. Geol. Surv.

[5] Apparently soon to become an important producer of manganese-ore.

[6] *The Mining Journal*, March 3, 1906, p. 287.

(*m*) Metric tons; otherwise in long tons.

Table 5.

Principal sources of Manganiferous Iron-ore and latest reported productions.

Country.	Year.	Production.
		Tons.
United States [1]	1904	383,246
Greece (Exports) [2]	1904	239,635 (*m*)
Germany [2]	1904	52,886 (*m*)
Belgium [2]	1903	6,100 (*m*)

2.—Mining Methods.

General description.

From the point of view of extraction of ore, the Indian manganese-ore deposits can be divided into two groups, namely:—

(*a*) those which form small hills ranging in height from 50 or 100 up to 250, 300, or even more, feet above the surrounding country; and

(*b*) those of which the highest points are—or rather *were*—either but a few feet above the plains or else just on a level with them.

1 "The Production of Manganese Ores in 1904," by J. Birkinbine, U.S. Geol. Surv.

2 "The Mineral Industry," 1904.

(*m*) Metric tons; otherwise in long tons.

Photo. by L. L. Fermor.

FIG. 11.—**Drilling Holes for Blasting the Manganese-ore.—Kándri.**

Working-face in level 2 of *Kándri* quarry. Except for a little of the country—possibly a metamorphosed grey-wacké—seen in the bottom right-hand corner, all the rock visible is merchantable manganese-ore. The well-marked slickensiding with cross-jointing divides the ore into large columnar prisms dipping at about 28° to E. 25° S. The men are engaged in drilling holes for blasting, after which large prismatic blocks of ore can be easily prized out with crow-bars. (18-1-04.)

Photo by L. L. Fermor.

FIG 12.—**Sampling Manganese-ore at Mansar.**

The ore was taken from holes selected at regular intervals in the stack of ore shown, broken up by cobbing-hammers and then reduced by coning and rejecting alternate sextants of the spread-out cone. This operation was repeated until the sample had been reduced to the required bulk. The coolies are engaged in rejecting alternate sextants. (28-1-04.)

In the former category may be placed the Jhábua deposit and many of those of the Central Provinces such as Kándri (see Fig. 10); while in the latter may be placed those of Madras and the remainder of those of the Central Provinces such as Kodur (Figs. 13 and 14), and Kodegáon (Fig. 9) respectively. In either case the excavations can only be described as quarries. Moreover, owing to the ease with which a large quantity of high-grade ore can be won, the methods of 'mining' employed are usually very crude. Thus ore has often been recklessly extracted to meet present demands and contracts without any regard either to geological considerations or to the future working of the deposit. This has frequently resulted in the subsequent discovery, either that the waste or *mati* has been dumped on to the hidden extension of the ore-body, or that so much dead-work will be necessary before the miner can work at a slightly increased depth, that it becomes a matter of doubt if the deposit can any longer be profitably exploited; such want of foresight and reckless working leads, of course, to a grievous waste of the country's mineral resources.

The only difference introduced by the situation of the deposit is that when working on a hill large quantities of ore can often be won for many years before quarrying down to the level of the surrounding plains. Consequently, there are no drainage troubles, and, as has been done at two 'mines,' Kándri (Fig. 10) and Mansar, the labour of transporting the ore can be greatly facilitated by the erection of aerial ropeways and inclined planes. On the other hand, in the case of an open quarry commenced at the level of the plains, as soon as a depth of 20 to 40 feet is reached, water troubles begin, so that extensive pumping is required, as at Kodur (Fig. 13); and eventually a depth is reached at which it becomes a matter of great difficulty to *quarry* the ore. It is

then that proper *mining* operations become necessary ; but it is more than doubtful if true manganese-mining can pay in India as long as there are so many deposits of manganese-ore in the world the mineral wealth of which is to be extracted by the simple methods usually employed.

In both classes of quarries nearly all work is done by hand. When in very hard, compact masses, the ore is first hand-drilled (Fig. 11) and then blasted. Otherwise it is simply prized out with crowbars, advantage being taken of the divisional planes of the ore-body when such are present. The huge blocks thus detached are broken up with heavy sledge-hammers and then, with but few exceptions, carried down the hill, or up out of the quarry, as the case may be, on the heads of women and children. At quite a number of quarries light rails have been put down to facilitate the disposal of both manganese-ore and waste. The ore is, if necessary, cleaned by women, children and old men, with small cobbing-hammers and finally piled into rectangular stacks ready for measurement. Where a chemist is employed, the stacks are usually sampled (Fig. 12) and assayed separately and the ore then carted or trammed—usually the former—to the railway station, where the products of different quarries are often mixed or blended so as to yield a cargo of a certain standard (Fig. 15).

As a further result of the abundance of easily-won ore, there seems to be but little desire to scientifically ascertain the structure, and consequently the future prospects, of the deposits ; and yet a few inexpensive cross-cuts at regular intervals would often yield a world of information. Instead of this, it is customary, in the case of open quarries in the ground, simply to follow an ore-body along its strike and to remove the over-burden of alluvium or soil as required, without any knowledge of what is to be expected next.

Photo by L. L. Fermor

FIG. 13.—**General view from E.N E. of the Manganese-ore Quarry, Kodur.—Vizagapatam District, Madras.**

The mound seen in the background is a waste-dump or *mati*-heap. The pumping-engines in the lower right-hand corner are for pumping out the water which accumulates in the pit during the rains, and when this has been accomplished, keeping down the constant influx of subterranean water. The step-like walls of the pit are necessary on account of the very soft rock—lithomarge, ochre and wad—of which they are composed.

Photo by L. L. Fermor

FIG. 14.—**East End of Kodur Quarry.**

The tunnels shown were made in an abortive attempt to 'mine' the ore-body by following it into the lithomarge. But owing to the soft character of the latter, the galleries could not be properly supported and it has been found necessary to quarry away both ore and country. The banded and streaked character of the country (lithomarge of different colours with wad and ochres) is seen at several points such as A, A, A. The ore and waste is carried out of the pit on the heads of coolies. (4-1-05.)

Kandri.

As a favourable contrast to these strictures on the methods of working, one or two deposits deserve especial mention. In the first place the working of Kándri—a hill 250 feet high—may be extolled as a model of how such a deposit should be developed. The ore-deposit, which forms a sort of backbone to the hill, is attacked by a series of levels at different heights, exposing both the ore-body and the country. As these are removed, the waste is conveyed by trucks on tram-lines and dumped over the end of the level remote from the working-face, so that the levels are constantly being extended away from the ore-body, the rails keeping pace with this growth. By means of a system of two aerial ropeways, an inclined plane and some zig-zag tramways, the labour of transport is greatly reduced. A general view of the working is shown in Fig. 10.

Bálághát.

The Bálághát deposit, also, is being well developed and has the advantage of an inclined haulage plane by which the ore is let down in trucks some 200 feet to a shoot for delivering ore into railway waggons on a small 2-mile branch line connecting up with Bálághát Ry. Stn., B.N.R.

Kájlidongri.

Finally, as the best example of the way to develop a deposit in a scientific fashion with a series of cross-cuts at intervals, enabling a rough estimate of ore-reserves to be formed, and serving also as passages for tram-lines, it is necessary to mention the Kájlidongri mine, Jhábua State, where the ore-deposit forms a long low mound rising some 60 to 70 feet above the *nálás* on either side (see Fig. 7).

3.—Economic Considerations.

Labour.

Both in Jhábua State, where the population is mainly Bhil, and in the Central Provinces where the inhabitants are chiefly Gonds and Hindus, labour is rather scarce and difficult to obtain. Consequently it is frequently imported. In the former case, Gujerátis from Ahmadabád, and in the latter, coolies from other districts of the Central Provinces, such as Raipur, have been tried. The best labour is undoubtedly that of Vizagapatam, where the Telugu-speaking natives accept smaller wages and seem to work considerably harder than the aboriginal people of Central India and the Central Provinces. The wages for the quarrymen range in different areas from two to four annas a day, and for women and children from one to two annas. The beneficial effect of manganese-mining on the native population was very noticeable during the last famine in the Central Provinces, when the natives round Rámtek, finding constant employment and wages in the neighbouring manganese-mines, to a large extent escaped from the worst effects of the famine. The following table[1] shows the daily[2] number of workers—men, women and children—employed in the manganese-quarries from 1895 to 1904.

[1] Compiled from the Annual Reports of the Inspector of Mines.

[2] In most cases the *average* daily number

Photo by L. L. Fermor.

FIG. 15.—**Unloading Manganese-ore from Buffalo-carts at Garividi Ry. Stn., E.C.R., Vizagapatam District.**

A hill of scapolitic gneiss in the distance. (6-1-05.)

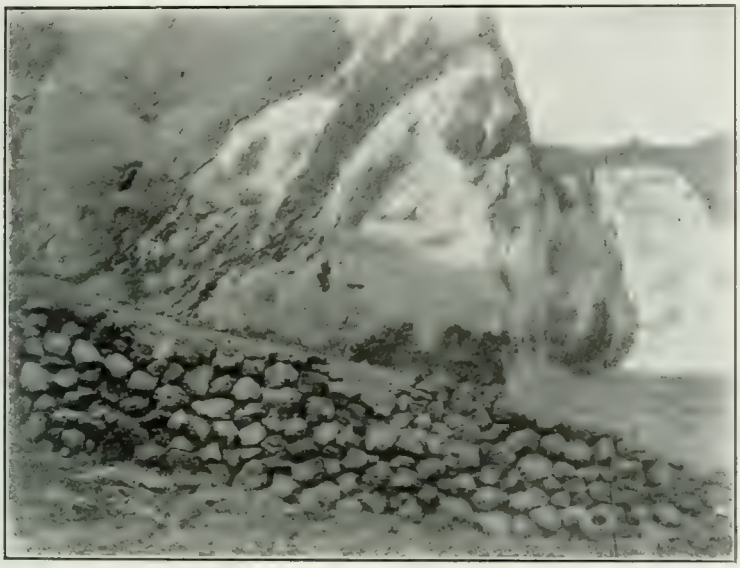

Photo by L. L. Fermor.

FIG. 16.—**Manganese-ore (black) forming by Replacement of Quartz-Felspar-Rock (white) at Garbham.—Vizagapatam District, Madras.**

Just to the left of the sledge-hammer is a nodule of manganese-ore right in the quartz-felspar rock. (23-12-04.)

TABLE 6.

Daily number of workers employed on the Manganese-quarries from 1895 to 1904.

Year ending	Bombay.	Central Provinces.	Madras.	Total.
30th June 1895 ...		...	600 to 1,100	600 to 1,100
30th June 1896	...	...	1,200	1,200
31st December 1897 ...	...	...	2,750	2,750
31st December 1898 ...		...	3,530	3,530
31st December 1899 ...	...	...	4,780	4,780
31st December 1900 ...	...	..	4,242	4,242
31st December 1901 ...	...	1,460	2,770	4,230
31st December 1902 ...	...	2,081	3,966	6,047
31st December 1903 ...	...	4,003	2,939	6,942
31st December 1904 ...	125	2,010	1,980	4,115
31st December 1905 ...	48	2,566	2,508	5,122 [1]

Cost of transport and production.

The chief items of expenditure incurred by the time the manganese-ore has reached a European or American port are those of freight, and these may be divided into :—

(1) the cost of carting or tramming to the railway station, which rises as high as Rs. 3 or Rs. 4 per ton in cases of carting over long distances—20 miles and upwards—but is usually much less and often, where tram-lines have been laid down, only a matter of annas ;

[1] To this is to be added 876, the number of workers at the Kájlidongri mine, making a total of 5,998 for 1905.

(2) the cost of railing the ore to the sea-ports, which on the scale of $\frac{1}{10}$th pie per maund per mile, works out as follows :—

	Rs.	As.	P.
Meghnagar (Central India) to Bombay (361 miles)	5	2	1
Nágpur to Calcutta (520 miles) ...	7	6	1
Nágpur to Bombay (701 miles) ...	9	15	3
Garividi to Vizagapatam (56 miles) ...	0	12	9

(3) the cost of shipping from one of the above ports to Europe or America ; this usually amounts to from 15 to 17 shillings per ton.

The remaining items of expenditure are cost of extraction, rent, establishment charges, depreciation of plant, royalties, cost of handling the ore at railway stations and ports, port dues, and agency and sampling charges at the port of destination. But these, even taken all together, are small compared with the total freight charges.

Taking the average manganese contents of the ores as 50%, it is seen that freight is also being paid on the remaining 50% of oxygen, silicon, iron, etc., which are either not wanted or else are not usually paid for. It is obvious that a great saving could be effected by the manufacture in India of the ferro-manganese and spiegel-eisen into which a very large proportion of these manganese-ores are converted. It will probably only need another slump in prices, a little worse than that of 1904, to either close down the majority of the manganese-quarries or to compel the owners to manufacture ferro-manganese locally, either for export as such or for use in the country when steel manufacture commences on a serious scale.

There are indications also that the cost of freight under (1) will, in many cases, be reduced in the future by the con-

struction of more tramways, and that many deposits, such as those of the Chhindwára district, Central Provinces, at present unworkable on account of their distance from the railway, will be connected up to the railway system of the country.

Prices and Valuation.

The prices per ton of manganese-ore obtained at the port of destination are subject to great variation according to the price per unit of manganese. The following table (No. 7) and the diagram

TABLE 7.

Variation in the Price of Manganese-ore c.i.f. at United Kingdom Ports.

Date.	First-grade ore.	Second-grade ore.	Third-grade ore.
	50 per cent. Mn. and upwards.	47–50 per cent. Mn.	40–47 per cent. Mn.
	Pence per unit.	*Pence per unit.*	*Pence per unit.*
January 1890	18–20	16–17	14–15
July 1890	16-18	14–15	12–13
January 1891 ...	15–17	12–14	12–14
July 1891	15–16	12–15	10–12
January 1892	14–16	12–14	9–12
July 1892	14½–15	13½–14	9–12
January 1893	14½–15	13½–14	9–12
July 1893	14–14½	11–13	9–11
January 1894	11½–12	9½–11	8–10
July 1894	10½–11½	9½–10½	8–10

Date.	First-grade ore. 50 per cent. Mn. and upwards. *Pence per unit.*	Second-grade ore 47–50 per cent. Mn. *Pence per unit.*	Third-grade ore. 40–47 per cent. Mn. *Pence per unit.*
January 1895	10½–11½	9–10	8–9
July 1895	10–11	9–10	7½–9
January 1896	11–13	10–12	9–11
July 1896	11–13	10–12	9–11
January 1897	11–13⅓	10–12	8–11
July 1897	9½–13	9–12	7½–10½
January 1898	9–12	8½–11	7½–10½
July 1898	9–12	8½–11	7½–10½
January 1899	10–12½	9–11	7½–10½
July 1899	12–14	10½–11½	8–10
January 1900	13–15	12–13	10–12
July 1900	13½–15	11½–12½	10–12
January 1901	12–14	11–12	11–12
July 1901	10½–11	9–10	–8
January 1902	9½–10½	9–9½	8–9
July 1902	9½–10½	9–9½	8–9
January 1903	10–10½	8½–9	7½–8½
July 1903	10–10½	8–9	7½–8½
January 1904	9–9½	8–9	6–8
July 1904	9–9½	8–9	6–8
January 1905	8¾–9¼	7½–8½	6–8
July 1905	9–10	8–9	6–8
January 1906	11–12	9–10½	7–9
May 1906	14–15	10–12	8–10

(Fig. 17) show the fluctuations in the price per unit of manganese-ore of different grades since 1890, as quoted by the Mining Journal. The connection between the ruling prices and the output of manganese-ore has already been considered (page 104).

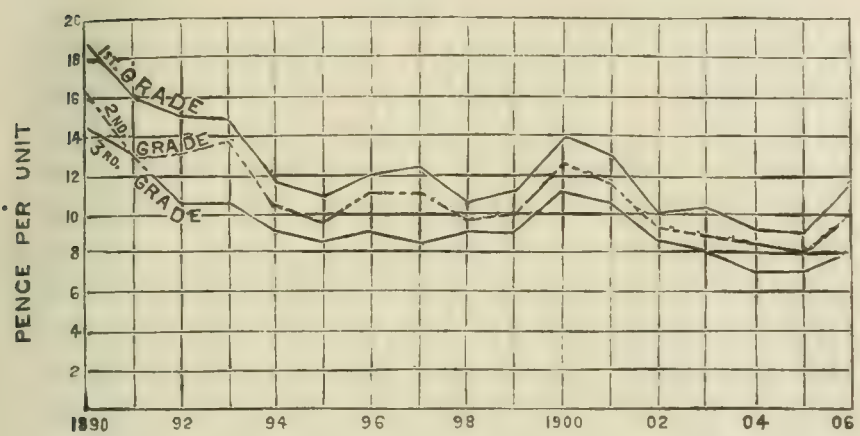

FIG. 17.—**Variation in the Prices of Managanese-ore at United Kingdom Ports since 1890.**

The prices given above are for the three grades into which manganese-ores are classified :—

1st grade	... ..	50 °/₀ Mn and upwards.
2nd do.	... ...	47-50 °/₀ Mn.
3rd do.	... ...	40-47 °/₀ Mn.

The average price paid at the end of 1904 for ore carrying 50 °/₀ and upwards of metallic manganese being taken as 9 pence, then a 52 °/₀ ore would be valued at $\frac{52 \times 9}{12} = 39$ shillings per ton.

For steel-making, manganese-ore should not contain more than 0·15 % of phosphorus or 10 % of silica, and on this basis ores delivered at the works of the Carnegie Steel Company at Pittsburg or Bessemer, Pa., U.S.A., are subject to acceptance or refusal at the buyer's option if containing less than 40 % of manganese or either phosphorus or silica in excess of the above limits. The Illinois Steel Co., according to a schedule based on ores containing not more than 8% of silica and 0·1 % of phosphorus, make deductions from the price of the ore of 15*c.* per ton for each 1 % of silica in excess of 8 % and of 1*c.* per unit of manganese for each 0·02 % of phosphorus in excess of 0·1 %.[1] An additional price per unit of iron present in the ore is sometimes paid by the steel-makers, but the practice as regards this varies. It will be noticed (see analyses on page 82) that the phosphorus contents of both the Central India and Madras ores exceed the above limits considerably. These ores, however, are sent to the Continent for mixing with iron-ores in the blast-furnace burden to produce a pig, low in sulphur but high in manganese and phosphorus, for use in the basic Bessemer process.

Distribution of the exported Indian manganese-ore.

The following table shows the destination of the manganese-ore exported from India from the year 1895-96 to 1904-1905.[2]

[1] Quite recently the schedule for both companies has been altered to a basis of 8 % of silica and 0·25 % phosphorus, deductions being made for every 1 % of silica and 0·2 % of phosphorus above these limits. Ore containing less than 40 % of manganese, or more than 12 % of silica, or 0·27 % of phosphorus, is subject to acceptance or refusal at the buyer's option.

[2] Annual statements of Trade and Navigation of British India.

TABLE 8.

Distribution of exported Indian Manganese-ore for the years 1895-96 to 1904-1905.

Year.	United Kingdom.	Belgium.	France.	Germany.	Holland.	Egypt	United States.	Other countries.	Total recorded export for the year.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons	Tons.		Tons.
1895-1896	19,358	...	.			...	3,400	...	22,758
1896-1897	42,630	...	...		...	...	4,700	...	47,330
1897-1898	54,279	...	...		...	...	24,550	...	78,829
1898-1899	51,931	...	...		...	...	10,944	..	62,875
1899-1900	63,175	5,350	...	..	8,350	...	18,350	.	95,225
1900-1901	86,269	13,300	5,850	...	16,500	3,400	5,350	.	130,669
1901-1902	65,150	...	.	11,300	..	15,000	41,720	...	133,170
1902-1903	95,540	1,000	..	10,734	5,050	...	42,950	Italy–1 cwt. Japan–1 cwt	155,274
1903-1904	110,506	19,288	2,050	9,985	3,500	..	35,860	.	181,189
1904-1905	64,705	25,015	10,800		5,300	10,750	64,375	...	180,945
Total sent to each country.	653,543	63,953	18,700	32,019	38,700	29,150	252190	...	1,088,264

The three great steel-producing countries—England, United States and Germany—take a large proportion of our manganese-ore; the exports to Holland and Belgium shown in the above table were in part for transmission to Germany, whilst the consignments sent to Egypt were booked to Port Said to await delivery to ports further west.

4.—USES OF MANGANESE.

It has already been shown how widespread is the element manganese in nature. The following list [1] will give

[1] Based on that of Penrose, An. Rep. of the Geol. Surv of Arkansas for 1890, Vol. I. "Manganese: Its Uses, Ores and Deposits," p. 7.

some idea of the numerous uses to which it has been applied by man :—

I.—Alloys
- Ferro-manganese. — Alloys of manganese and iron.
- Spiegel-eisen. — Alloys of manganese and iron.
- Manganese-steel — Alloys of manganese and iron.
- Ferro-silicon — Alloy of manganese, iron and silicon.
- Manganese-bronze. — Alloy of manganese and copper with or without iron.
- Silver-bronze. — Alloy of manganese, aluminium, zinc and copper.
- Alloys of manganese with aluminium, zinc, tin, lead, magnesium, etc.

II.—Oxidizers
- Manufacture of chlorine, bromine and bleaching powder.
- Decolourizer of glass.
- Dryer in varnishes and paints.
- Leclanché's cell.
- Preparation of oxygen on a small scale.
- Manufacture of disinfectants (manganates and permanganates.)

III.—Colouring materials
- Calico-printing and dyeing.
- Colouring glass, pottery, tiles and bricks.
- Paints ... Green. Violet.

IV.—Various lesser chemical, manufacturing and medical purposes.

V.—Occasionally as a gem when in the form of rhodonite or spessartite.

VI.—Occasionally as a flux in smelting silver-ores.

Spiegel-eisen and ferro-manganese.

In all probability at least 90 % of the world's output of manganese-ore is consumed in the manufacture of iron and steel. The manganese-ore is first smelted in blast-furnaces into either spiegel-eisen or ferro-manganese. *Spiegel-eisen* is an alloy of iron

and manganese containing usually 5 to 27 % of manganese and 4 to 5 % of carbon. *Ferro-manganese* is a similar alloy containing from 27 to 86 % of manganese and about 6 to 7 % of carbon. These two alloys are largely used in the Bessemer and open-hearth processes for making both acid and basic mild steel, and are in all cases added at the end of the process, and this chiefly for two purposes:—

(1) to remove any oxygen taken up by the bath of molten metal.

(2) to supply the requisite amount of carbon to the steel.

A small proportion of the manganese remains in the metal, but by far the larger proportion of it passes into the slag.

Manganese-steel.

Manganese-steel contains a considerably higher percentage of manganese than is present in all ordinary steels. With amounts of manganese between 7 and 20 % an extraordinarily strong, tough, and practically non-magnetic metal is the result. These alloys were investigated by Hadfield, and the well-known Hadfield Era steel contains about 13 % of manganese and 1 % of carbon; although, on account of its extreme hardness, very difficult to work, it is now being extensively used for many purposes where combined hardness, toughness and consequent great power to resist grinding wear are required. Among such applications may be mentioned all kinds of mining machinery, especially that used for milling and crushing, such as jaws of rock-breakers, crusher-heads, rolls, etc., and also for mine-car wheels and dredging machinery. Manganese-steel has also been used for tools such as axes and razors. It is interesting to notice in this latter connection

Kheri.

that at Ghogra in the Jabalpur district, Central Provinces, a manganiferous iron-ore is still being smelted in small native iron-furnaces, and

that the product is a rather hard steely iron known as *kheri*, in great demand in the surrounding country where the *lohárs* weld it on to ordinary locally made soft iron to form the edges of axes and scythes, the striking faces of hammers and the heads of anvils. Though it has not yet been analytically tested, yet this *kheri* perhaps owes its superior hardness over the local soft iron to a certain percentage of manganese derived from the ore.[1]

Glass, enamel, pottery.

Turning now to the other uses of manganese we find that, from very ancient times, there has probably been a small consumption of manganese-ore by the natives of India for colouring glasses and enamels, it being possible to impart green, violet, brown and black tints by the use of this substance. Messrs. Burn and Co., moreover, use a small amount of manganese-ore from the Jabalpur district for imparting dark brown and black body colours to earthenware, such as tiles, and for producing chocolate and black glazes on ordinary biscuit-ware, such as teapots. I am not aware that manganese-ore has been used in India for any other of the purposes enumerated, but considering the large consumption of bleaching powder in paper mills, one would think it would be worth while manufacturing this substance in India.

Ornamental applications.

Moreover, I would draw attention to the fact that many of the manganese-ore desposits of the Central Provinces contain considerable quantities of rhodonite, at present being consigned to the dump-heap; but that the rhodonite from other parts of the world, especially the Ural Mountains, is often used as an ornamental stone. It would be difficult to find a more beautiful ornamental stone than the pink rhodonite with delicate veins of

[1] Mallet, *Rec. G. S. I.*, XVI, p. 101, (1883).

black manganese-oxide, such as occurs at Mánegáon, Nágpur district, or than the rhodonite studded with orange spessartite, such as is found at Chárgáon, Nágpur district, and in the Chhindwára district. In the United States, moreover, spessartite when found clear and transparent is sometimes turned to account as a very beautiful gem-stone of orange and red colours.[1] I have not seen any Indian spessartite, except very small crystals, sufficiently clear for this purpose, but it is as well to keep it in view.

5.—Future Prospects of the Manganese-ore Mining Industry in India.

It will be noticed that no estimate has been given in this paper of the quantities of manganese-ore available in the deposits. This is not, however, because there is any need for pessimism on the subject. It is true that in the Vizagapatam district it is becoming more difficult to quarry the ore owing to the increasing depth at which it has to be worked; but in the Central Provinces there are several deposits concerning which it is easy to form estimates indicating the presence of millions of tons of ore easy to win. Owing, however, to the insufficient work which has been carried out in the way of cross-cuts and bore-holes, as already mentioned (page 108), these estimates are more or less of guesses, but there can be no doubt whatever of their general correctness in pointing to the presence in the Central Provinces of vast quantities of easily quarried manganese-ore.

Nevertheless, at the present rate of output, with the rejection of all but first-grade ore, there does not seem to be much doubt that within a comparatively small period of time, which one might guess at 30 to 50 years, the majority of the

[1] Kunz, "Gems and Precious Stones of North America," p. 79, (1890).

deposits at present known will have been worked out as far as the application of present methods of extraction are concerned. There will then still be left, both in the ground and on the dump-heaps, millions of tons of second and third-grade ores and vast quantities of manganese-silicate-rock consisting largely of spessartite and rhodonite, and often carrying as much as 30 or 40 per cent. of manganese.

This might be considered as rather an alarming prospect but for two counterbalancing considerations. One is that the deposits of manganese-oxide ores throughout the world are strictly limited in quantity, so that within a comparatively short time, which might be guessed as 100 years as a maximum, unless several fresh areas containing such deposits be discovered, all the easily won ores will have been removed from the earth. Long before that time, however, the price per unit of manganese will rise sufficiently to enable the lower grade ores of the world, if not smelted on the spot, to be transported profitably to the smelting centres. Long before that time also the increasing difficulty and cost of getting manganese-oxide ores will probably compel metallurgists to turn their attention to the silicate-ores.

The second consideration is that long before that time, and let us hope in only a few years from the present, ferro-manganese smelting will probably have been introduced into India, thus rendering valuable the low-grade ores at present rejected, and so to a certain extent conserving the higher grade ores.

We are thus able to picture that within a comparatively small number of years, the easily-won high-grade Indian oxide-ores will become quite limited in quantity, and that, with the rising prices due to a similar state of affairs in other parts of the world, the manganese-miners will then find it just as profitable to work the lower grade ores and sort over

their dump-heaps as the tin-miners recently have in Cornwall to search their waste heaps for wolfram. Following this, will come the time when spessartite and rhodonite will be regarded as ores and just as eagerly sought as 50 per cent. oxide-ores now are.

Keeping in view these three stages of manganese-mining—high-grade oxide-ores, low-grade oxide-ores, and silicate-ores, being each in turn the substance sought—it can confidently be predicted that manganese-"quarrying," and later on perhaps, manganese-"mining," has in India a long and prosperous future with possibly, however, bad times at intervals.

Nevertheless, it would not be out of place to draw attention to the desirability of stocking the low-grade and silicate-ores separately from the country-rock of quartzite, mica-schist, gneiss or lithomarge, with which they are often indiscriminately mixed when consigned to the waste-heaps.

Another aspect of the question has already been noticed by Mr. Holland,[1] namely, the heavy loss which India, to all intents and purposes, suffers by exporting the raw ore. The average price that Indian manganese-ore fetches at its destination is about Rs. 30 per ton and of this only about one-half goes to India, being divided between railways, carters, miners and land-owners. The remaining Rs. 15 goes mainly in freight charges. The manganese then comes back to India in the form of the steel it has helped to make, and India pays both the foreign manufacturer's profits and the cost of return carriage. A recent quotation in the *Engineering and Mining Journal*[2] gives the price per ton of 80 % ferro-manganese as $75 to $175, equivalent to about Rs. 265 to Rs. 546. It becomes obvious from this how desirable it is to manufacture ferro-manganese in India and thus keep in the

[1] *Rec. Geol. Surv. Ind.*, XXXII, p. 62, 1905).

[2] Jan. 27th 1906, p. 212.

country a proportion of the profits involved in its manufacture, even if the larger part of the ferro-manganese so made has still to be exported. The time must come, however, when the manufacture of iron and steel will be one of India's most important industries, and then, of course, India will consume a large proportion of its own ferro-manganese.

IV.—CONCLUSION.

It has been my aim in this paper to put before the members of the Institute a general account of the manganese-ore deposits of India and of the industry which depends upon them. Under present conditions it would be difficult to arouse more interest in them from the economic aspect, but I hope that this paper will help to a better understanding of the structure and nature of the deposits with a consequent more scientific method of working them, and that it will arouse interest in them from the mineralogical point of view by drawing attention to the fact that the Indian manganese-ore deposits are wonderful repositories of rare and often exceeding beautiful minerals. Mr. F. R. Mallet,[1] in 1887, remarked on the paucity of well-crystallized and beautiful minerals which have been found in India, and he rightly ascribed this to the small amount of mining which had been seriously attempted. Now that manganese-mining has become so important, a magnificent opportunity presents itself for the collection of such minerals, and manganese-miners would be conferring an obligation on science if they would interest themselves in the matter, and keep on the look-out for the occasional fine crystallizations which must occur even in the most solid-looking ore-bodies, and which the geologist, during

[1] *Manual of Geology of India*, IV, Mineralogy, Preface, pp. v & vi.

a brief visit to the mine, would only light upon by the happiest chance.

Finally, I should like to take this opportunity of expressing my thanks to the managers of the manganese-mines for the courtesy with which they gave me every facility for examining their properties.

V.—GEOGRAPHICAL INDEX.

	Latitude, N.	Longitude, E.
A		
Aitemvalsa	18° 23′	83° 39′
Alesur	21° 43′	78° 57′
Arjoni	21° 46′	79° 57′
Asalpáni	21° 30′	79° 43′
Avagudem	18° 21′	83° 36′
B		
Bálághát	21° 48′	80° 15′
Bansinghi	21° 22′	79° 12′
Beldongri	21° 20′	79° 21′
Bhandárbori	21° 24′	79° 31′
Bichua	21° 42′	78° 55′
Boiráni	19° 35′	84° 49′
Bondapilli	18° 22′	83° 39′
Borda	21° 27′	79° 20′
C		
Cháibása	22° 33′	85° 52′
Chándadoh	21° 42′	79° 44′
Chárgáon	21° 24′	79° 21′
Chikhla I	21° 33′	79° 49′
Chikhla II	21° 41′	79° 58′
Chik-Vadvati	15° 10′	75° 47′
Chintelavalsa	18° 25′	83° 17′

	Latitude, N.	Longitude, E.
D		
Devádá	18° 15′	83° 38′
Devi	21° 42′	78° 57′
Dudhára	21° 30′	78° 57′
Dumri Kalán	21° 20′	79° 18′
Duvvám	18° 15′	83° 36′
G		
Gadasám	18° 21′	83° 28′
Gaimukh	21° 45′	78° 54′
Garbhám	18° 22′	83° 31′
Garividi	18° 17′	83° 36′
Garraráju Chipurupalli (Garuja) .	18° 24′	83° 41′
Ghogara (Pench River)	21° 23′	79° 14′
Ghogra	23° 29′	80° 15′
Ghondi	21° 56′	80° 29′
Ghoti	21° 38′	78° 56′
Gosalpur	23° 24′	80° 7′
Gotnandi	18° 23′	83° 39′
Govindapuram	18° 15′	83° 45′
Gowári Warhona	21° 32′	78° 53′
Guguldoho	21° 26′	79° 29′
Gumgáon	21° 24′	79° 3′
H		
Hatora	21° 37′	79° 52′
I		
Itakerlapilli	18° 15′	83° 40′
J		
Jám	21° 45′	79° 57′
Jámbughoda	22° 22′	73° 48′
Jamrapáni	21° 40′	79° 47′
Jothvád	22° 23′	73° 47′
Junapáni	21° 29′	79° 23′
Junawáni	21° 29′	79° 21′

	Latitude, N.	Longitude, E.
K		
Kácharwáhi	21° 20′	79° 27′
Kachi Dhána .. .	21° 43′	78° 51′
Kájlidongri	22° 57′	74° 31′
Kándri	21° 25′	79° 20′
Katangjheri I (Govt. Forest) ...	21° 51′	80° 0′
Katangjheri II (Málguzári) ...	1° 50′	80° 1′
Khandála	21° 20′	79° 29′
Kodegáon	21° 25′	79° 1′
Kodur	18° 16′	83° 37′
Kosumbah	21° 38′	79° 42′
Kotakarra	18° 22′	83° 33′
Kurmura	21° 32′	79° 44′
L		
Lakhanwára	21° 45′	78° 54′
Lohdongri	21° 20′	79° 25′
M		
Mahábaleshvar	17° 56′	73° 43′
Mándri .	21° 25′	79° 28′
Mándvi Bir	21° 29′	79° 17′
Mánegáon	21° 26′	79° 28′
Mansar . .	21° 24′	79° 20′
Miragpur	21° 38′	79° 54′
Mohugáon	21° 27′	79° 5′
Mohugáon Ghát .	21° 37′	79° 54′
Mulagám	18° 14′	83° 41′
N		
Nagardhan ..	21° 20′	79° 23′
Nandapuri	21° 20′	79° 23′
Nándgáon	21° 49′	79° 58′
Nándgondi	21° 30′	79° 7′
Nautan-Barampur	19° 36′	85° 6′

	Latitude, N.	Longitude, E.
P		
Pachára	21° 27′	79° 50′
Páli	21° 26′	79° 15′
Pándarwáni	21° 37′	79° 54′
Pársioni	21° 22′	79° 13′
Parsoda	21° 23′	79° 22′
Pench River—see Ghogara	...	...
Perapi	18° 16′	83° 41′
Perumáli	18° 26′	83° 38′
Ponia	21° 43′	79° 49′
R		
Rámabhadrapuram	18° 30′	83° 20′
Rámandrug	15° 7′	76° 32′
Rambhápur	22° 55′	74° 32′
Rámdongri	21° 25′	79° 5′
Ramrama	21° 51′	79° 59′
Rámtek	21° 24′	79° 23′
Risára (Reechara)	21° 28′	79° 3′
S		
Sálebaddi	2 ° 40′	79° 56′
Sandanandapuram	18° 14′	83° 37′
Sátak	21° 20′	79° 20′
Sihora	23° 29′	80° 10′
Sitagondi	21° 29′	79° 8′
Sitapár	21° 44′	78° 56′
Sitapathur	21° 42′	79° 44′
Sitasáongi	21° 31′	79° 48′
Sivarám	18° 16′	83° 39′
Sivarájpur	22° 25′	73° 40′
Sonegáon	21° 41′	79° 50′
Sukli	21° 40′	79° 44′
T		
Táduru	18° 25′	83° 13′
Talevadi .	15° 33′	74° 24′
Thirori	21° 41′	79° 47′
Thonaum	18° 39′	83° 11′

	Latitude, N.	Longitude, E.
U		
Ukua	21° 58′	80° 32′
W		
Wagora	21° 36′	78° 52′
Waregáon	21° 20′	79° 28′
Y		
Yeruli	18° 2′	73° 54′

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PLATE 1.

Map of India showing the situation of the more important manganese-ore deposits.

PLATE 2.

Geological sketch-map of the Nágpur-Bálághát area, Central Provinces, showing the situation of the manganese-ore deposits.

PLATE 3.

Map of a part of the Vizagapatam district, Madras Presidency, showing the situation of the manganese-ore deposits.

NOTES, ABSTRACTS, AND REVIEWS.

NEW MANGANESE-ORE OCCURRENCES IN BRITISH NORTH BORNEO (Neue Manganerz-Vorkommen in Britisch Nord-Borneo), by Dr. Arthur Dieseldorff. *Zeitschrift für prak. Geol.* XIV, pp. 10, 11, (1906).

This short note gives a brief account of the numerous deposits of manganese-ore recently discovered in the Marudu Bay area of British North Borneo, Taritipan being the centre. The ore-bodies crop out over a large area of country, and quarrying is being vigorously prosecuted at several localities. The ore-bodies are of large size and are accompanied by jaspery or flinty siliceous schists (Kieselschiefern). The chief ore is psilomelane, but in some places, such as Kakukuja, pyrolusite is also found.

All the ores (except the pyrolusite which contains as much as 8 per cent. BaO) are free from copper, arsenic, nickel and baryta, and contain only very small quantities of phosphorus and sulphur.

The following analyses show the quality of the ores :—

	Average sample of ship cargoes (I).	Sample from selected ship cargoes (II).
Manganese	49–51 %	51–53 %
Silica	15	8–10
Phosphorus	0·03	0·04
Sulphur	0·035	0·04

It is stated that the average ore exported from the different deposits consists of 65 per cent. of No. I, and 35 per cent. of No. II, and that the average of all the ores is 50·4 per cent. Mn and 14·6 per cent. SiO_2. The ore being very hard psilomelane it absorbs, even in the rains, only up to 6 per cent. of water. Iron is under 2 per cent.

It will be noticed that though these ores are superior to the Indian manganese-ores as regards phosphorus contents, yet they are extremely high in silica, so high in fact that the average ore lies outside the limits of silica (8–10 per cent.) usually permitted. It is said, however, that the ores are being actively exported, and it is estimated that the least quantity which will be exported for the next 25 years will be 50,000 tons per annum.

The possibility of manufacturing ferro-manganese on the spot is also considered. It appears that an excellent limestone is available as a flux but that wood-charcoal would have to be used as fuel.

L. L. FERMOR.

ON THE MANUFACTURE OF FERRO-MANGANESE (Uber die Herstellung von Ferromangan) by Director Oscar Simmersbach, Düsseldorf. *Berg- und Hüttenmännische Rundschau*, I, 305-308 (1905).

The literature on the subject of the manufacture of ferro-manganese is very scanty, and hence this paper is to be welcomed as it contains in a comparatively small space most of the essential facts bearing on this question.

According to the author, spiegel-eisen contains up to 27 % manganese, at which point the alloys completely lose the magnetic properties hitherto possessed. With 27 % and upwards of manganese, the alloys are known as ferro-manganese. Dr. Prieger of Bonn first showed it to be possible to alloy manganese with iron in high proportions and thus laid the scientific foundations of the manufacture of ferro-manganese. The work of W. Henderson of Glasgow on this subject appears to have been later than that of Prieger.

The author states that the ores best suited for the manufacture of ferro-manganese in the blast-furnace are rhodochrosite and manganite, but that these ores, as well as hausmannite and psilomelane[1] are not

[1] He gives the formula Mn_2O_8 for psilomelane. This is, of course, incorrect as this mineral is usually, and probably correctly, regarded as a manganate corresponding to the hypothetical acid H_4MnO_5; psilomelane, moreover, is one of the commonest and most widespread of the ores of manganese, at least as far as India and Borneo are concerned. Considering also the important position as a producer of manganese-ore which India now takes, braunite ($3Mn_2O_3 . MnSiO_3$), which together with psilomelane constitutes the main bulk of the ore exported, certainly requires mention.—L. L. F.

so abundant and widespread in nature as pyrolusite and wad. The valuation of manganese-ores depends largely on the percentage of phosphorus present and to a less degree on the percentage of silica; for both these constituents influence the quality of the ferro-manganese. Spiegel-eisen with 20 % Mn should not contain more than 0·1 % P, and for every 10 % Mn above this the phosphorus contents should not increase by more than 0·02 %, so that ferro-manganese with 80 % Mn should not contain more than $0·1 + (6 \times 0·02) = 0·22$ % P. The standard for silicon is spiegel-eisen containing 20 % Mn and 1 % silicon with a permissible increase of 0·1 % Si for every 10 % increase in the manganese; hence 80 % ferro-manganese should not contain more than $1·0 + (6 \times 0·1) = 1·6$ % silicon.

Those oxides of manganese, such as pyrolusite and psilomelane, which contain a high proportion of oxygen, are changed whilst still at the comparatively low temperature of the upper part of the blast-furnace into lower states of oxidation ($3MnO_2 = Mn_3O_4 + O$), the oxygen set free uniting with the carbon of the fuel. At lower levels the following change takes place:—$Mn_3O_4 + CO = 3MnO + CO_2$. Both these reactions take place with considerable development of heat so that the walls and throat of the furnace are quickly destroyed. This also leads to an increased consumption of fuel, and the question therefore arises as to whether in smelting ores rich in oxygen it would not be desirable to previously roast them by means of the gases which can be drawn off at the mouth of the furnace. Lower down still the manganese-protoxide is reduced by the solid carbon in accordance with the equation $MnO + C = Mn + CO$; but also partly according to the equation $MnO + CO = Mn + CO_2$.

In manufacturing ferro-manganese the consumption of fuel is much greater than in smelting cast-iron. The chief reason for this is the necessity of maintaining a higher temperature owing to the fact that the heat of the oxidation of manganese referred to the unit of oxygen is greater than that of iron, so that more heat is consumed in breaking down the oxides of manganese. In general, while 100 % of coke is required for the reduction of iron, 250 % is required for the reduction of manganese.

The charge must be calculated so that the oxygen of the earthy bases, lime, magnesia and alumina, is at least as great as the oxygen

of the silica. The chief point seems to be that the slag must be sufficiently basic, as otherwise not only is too little manganese reduced but there is then a risk of producing, at the high temperatures prevailing, a silicate of ferro-manganese instead of ferro-manganese itself. Good ferro-manganese slags contain 7 to 10 °/₀ Mn according to the composition of the ferro-manganese, but up to 18 or 20 °/₀ Mn is not uncommonly found in the slag when easily fusible ores are smelted.

The profiles of three blast-furnaces, from South Russia, Austria and Germany, respectively, are given, together with a table of analyses of ferro-manganese slags produced from them.

In addition to the loss of manganese by passage into the slag, volatilization of manganese also takes place in the blast-furnace, because the volatilization temperature of manganese lies below that of the production of ferro-manganese. The loss due to this cause ranges up to 17 °/₀ and over of the original manganese-contents. This manganese becomes oxidized in the throat of the furnace and the brown smoke thus produced quickly destroys the conduits, as it forms readily fusible silicates with the stone-work. Considerable losses of manganese also take place on tapping, owing partly to volatilization from the molten bath of metal, and partly to oxidation by the air ; but by shutting off the blast these losses can be much reduced.

A table of analyses of ferro-manganese from various localities shows the following limits :—

	Per cent.
Manganese ...	76 to 85
Iron	14 to 6
Phosphorus ...	0·20 to 0·36
Carbon	5·98 to 7·20
Silicon	0·50 to 1·47

A table of the cost of production in South Russia of 80 °/₀ ferro-manganese and 20 °/₀ spiegel-eisen gives the total cost per ton as 183·18 and 95·97 marks respectively, corresponding roughly to £9-3-0 and £4-16-0 respectively.

Owing to the decomposition which ferro-manganese suffers when exposed to the weather, it is necessary to store it under cover.

L. L. FERMOR.

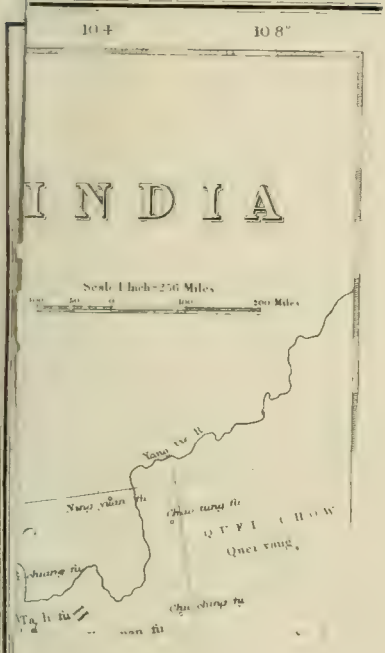
THE DEMAND FOR MANGANESE-ORES (Die Deckung des Bedarfs an Manganerzen), by W. Venator. *Stahl u. Eisen*, January 15, and February 1, 1906; 17 pages. Translated in the Mining Journal, LXXIX, 178, 179, 243, 277, (1906).

This paper gives an account of the various factors which create a demand for manganese-ores, of their valuation, and of their production and consumption by various countries. Taking an average of 1 per cent. of metallic manganese as necessary per ton of steel produced, the author is able to account for the annual consumption of about 900,000 tons of 50 per cent. ore (900,000 to 1,000,000 tons of ore of various grades is the world's annual output).

The method of working manganese-ore deposits is almost universally primitive, but the author mentions some experiments which have been conducted in Germany and which indicate the possibility of concentrating low grade siliceous ores so as to produce a higher grade less siliceous material. The advantages of a briquetting process, could a satisfactory one be devised, for treating such friable and wet ores as those of Brazil, are also discussed.

A short account is given, taking more the form of a list, of the manganese-ore localities of each producing country. There are several mistakes in the orthography of the names of Indian localities. Two statements to which exception must be taken are (1) that Russia, at the present time, possesses nearly a monopoly of high-grade manganese-ores, and (2) that the Russian deposits are the thickest known. In the first place India and Brazil together produce annually from 300,000 to 500,000 tons of manganese-ore (mostly high-grade), while the annual Russian production averages about 500,000 tons, but has probably been during the last year (1905) below the total of Indian and Brazilian production. In the second place the ores of the Caucasus, from which by far the largest proportion of the Russian manganese-ores come, occur in a bed which averages only some 5 to 8 feet in thickness, while many of the Brazilian and Indian deposits are from 50 to 100, or even more, feet thick.

L. L. FERMOR.


104
108
INDIA
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200 Miles
Yang tze R.
Nang yuen fu
Chau tung fu
Qnei tung
Chu shung fu

MAP OF THE CHIEF OCCURRENCES of MANGANESE-ORE IN INDIA.

INDEX TO NUMBERS.

(Manganese-ore deposits of proved economic value are found in the Districts and States underlined.)

BENGAL
1. *Kálahandi*
2. *Singhbhum*

BOMBAY
3. *Belgaum and North Kanara*
4. *Bijapur*
5. *Dhárwár (Sangli State)*
6. *Nárukot and Panch Mahála*
7. *Sátára*

BURMA
8. *Mergui*

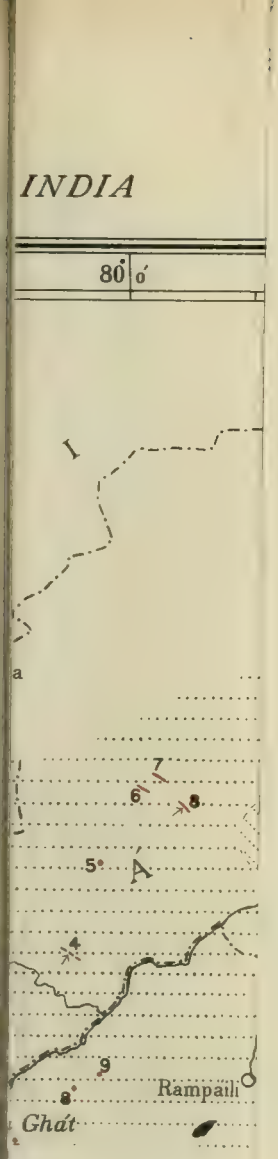
CENTRAL INDIA
9. *Dhár and Indore*
10. *Gwalior*
11. *Jhábua*

CENTRAL PROVINCES
12. *Bálághát*
13. *Bhandára*
14. *Chhindwára*
15. *Hoshangábád*
16. *Jabalpur*
17. *Nágpur*
18. *Wun*

HAIDARABAD
19. *Bidar*

MADRAS
20. *Bellary (Sandur Hills)*
21. *Ganjám*
22. *Vizagapatam*

MYSORE
23. *Chitaldrug*
24. *Shimoga*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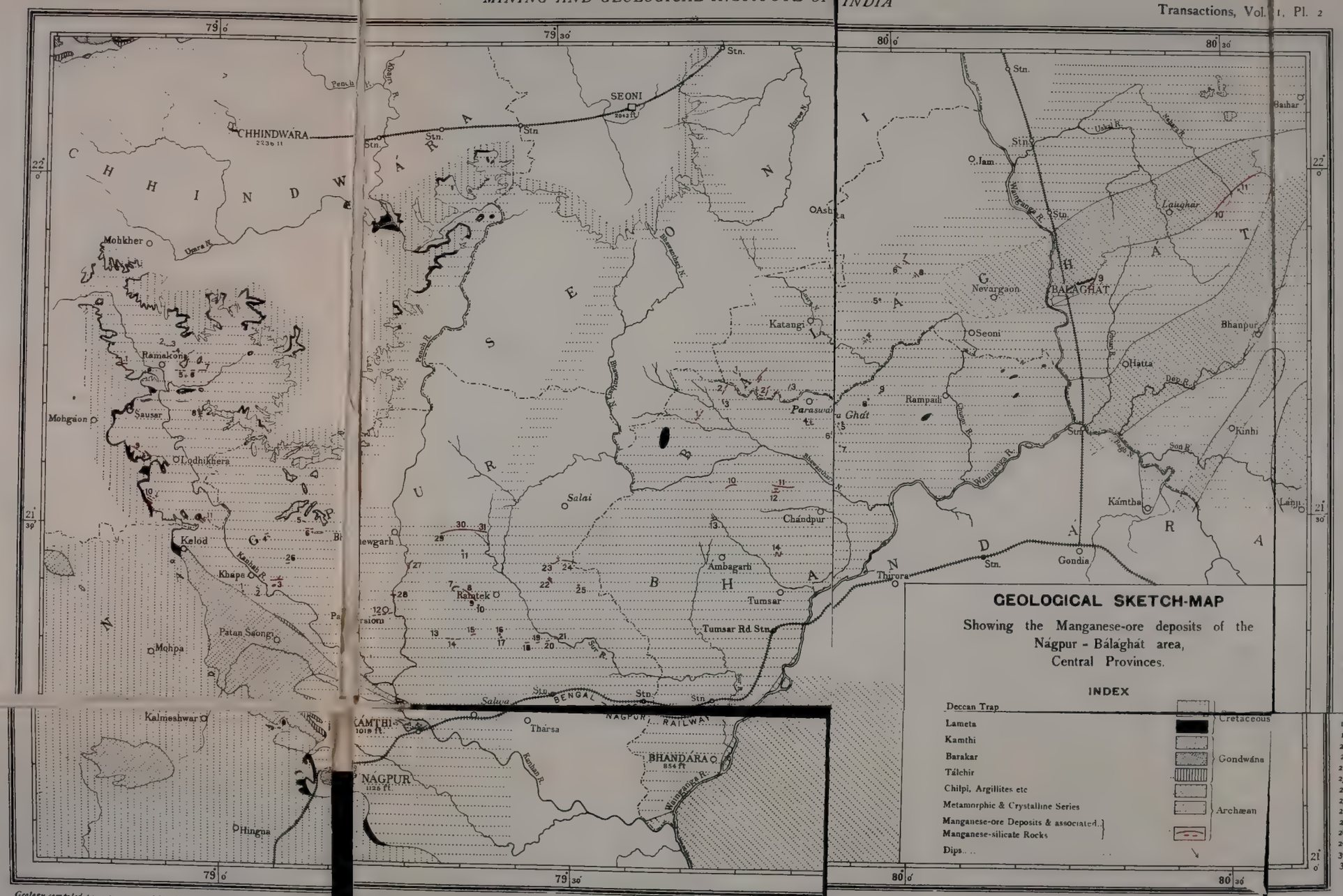
6
8
5
A
4
9
8
Rampaili
Ghát



GEOLOGICAL SKETCH-MAP

Showing the Manganese-ore deposits of the Nágpur - Bálaghát area, Central Provinces.

INDEX

Deccan Trap	Cretaceous
Lameta	Cretaceous
Kamthi	Gondwána
Barakar	Gondwána
Tálchir	Gondwána
Chilpi, Argillites etc	Archæan
Metamorphic & Crystalline Series	Archæan
Manganese-ore Deposits & associated Manganese-silicate Rocks	
Dips	

Index to Numbers.

Balaghat district

1. Chandadoh
2. Thiroti, Ponia and Jamrapan.
3. Sonegaon
4. Arjoni and Jám
5. Nandgaon
6. Ramrama
7. Katangjheri I (Govt. Forest
8. Katangjheri II (Málguzari)
9. Balaghat
10. Ghondi
11. Ukua

Bhandara district.

1. Kosumbah
2. Sitapathur
3. Sukli
4. Hatora
5. Miragpur
6. Mohugaon Ghát
7. Pándarwáni
8. Salebaddi
9. Chikhla II
10. Kurmura
11. Chikhla I
12. Sitasaongi
13. Asalpáni
14. Pachára

Chhindwara district

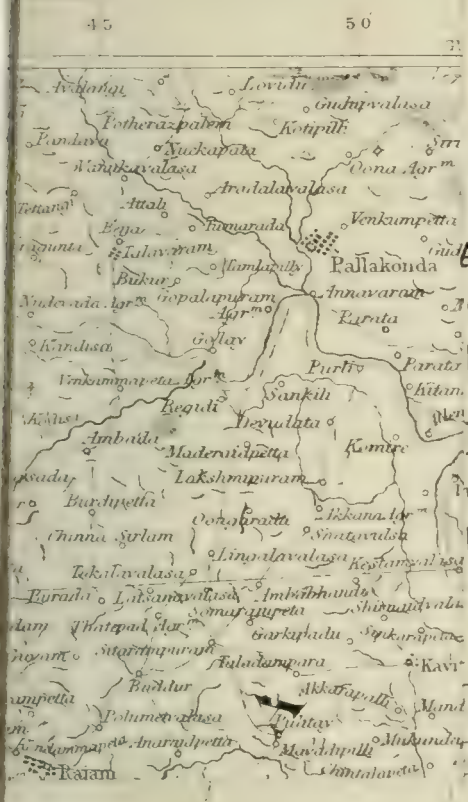
1. Kachi Dhána
2. Lakhanwára
3. Gaimukh
4. Sitapár
5. Bichua
6. Alesur
7. Devi
8. Ghoti
9. Wagora
10. Gowári Warhona
11. Dudhára

Nagpur district.

1. Kodegaon
2. Gumgaon
3. Ramdongri
4. Risára (Reechara)
5. Nandgondi
6. Sitagondi
7. Kándri
8. Mansar
9. Mansar Extension
10. Parsoda
11. Borda
12. Parsioni and Bansinghi
13. Dumri Kalan
14. Sátak
15. Beldongri
16. Nagardhan
17. Naoligaon
18. Lohdongri
19. Kacharwáhi
20. Waregaon
21. Khandála
22. Mándri
23. Mánegaon
24. Guguldoho
25. Bhandárbori
26. Mohugáon
27. Pálí
28. (Pench River) Ghogara
29. Mándvi Bir
30. Junawáni
31. Junapani

Geology compiled from the maps of W. T. Blanford, P. N. Bose, P. N. Datta, L. L. Fermor, E. J. Jones & Lala Kishen Singh.

Scale 1 inch = 8 miles



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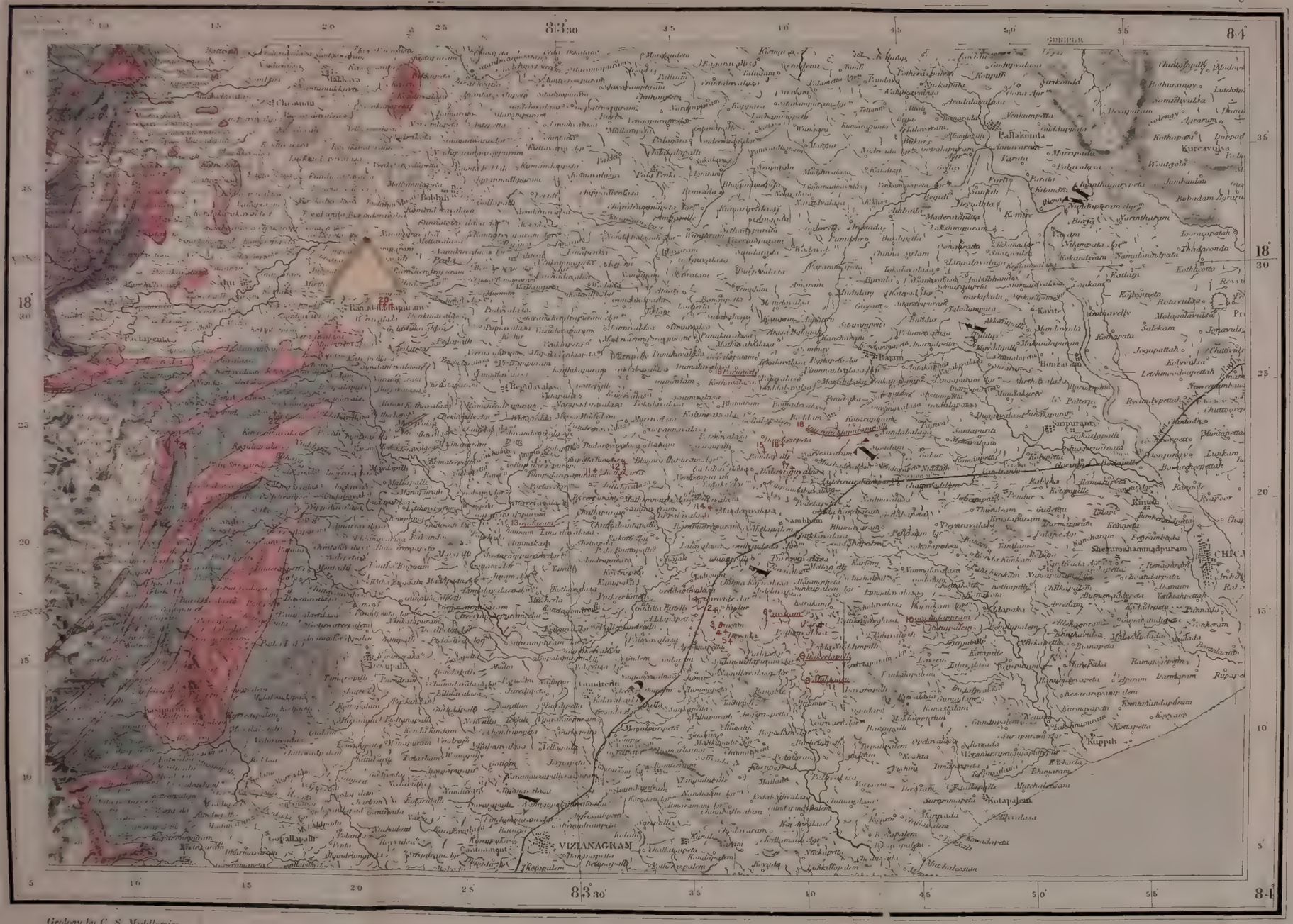

MAP

OF A PORTION OF THE

VIZAGAPATAM DISTRICT

MADRAS PRESIDENCY

showing the

MANGANESE-ORE LOCALITIES.

Scale 1 = 4 Miles.

LEGEND.

Index to Manganese-ore Localities.

+ *Indicates situation of deposit. When this is not known the village name is underlined in red.*

1	Garividi	13	Gobusam
2	Kothur	14	Avagadem
3	Duvvam	15	Attamalsa
4	Devada	16	Gotandi
5	Sandamandapuram	17	Boudapalli
6	Sivarama	18	Garrapaju Chipurupalli
7	Peripi		(Garapu)
8	Itakerlapalli	19	Perumali
9	Mulajam	20	Ramabhadrapuram
10	Gurnalapuram	21	Taburu
11	Garbham	22	Chintalavalsa
12	Kotakarra (I & II)	23	Thonam

Geology.

The whole area of this map is occupied by Archæan rocks well exposed in the Eastern Ghâts, the former of which appears at the western edge of the map, where they have been mapped as -

(1) Gneissose Granite

(2) Charnockite Series

(3) Khondalite Series

The larger part of the area, however, is occupied by plains of alluvium and laterite, formed by alluvium and where these three groups of rocks have not been separately mapped.

Geology by C. S. Middlemiss.

General Meeting.

Held at the Barakar Iron and Steel Works, Monday, March 26th, 1906.

Mr. T. H. Holland, President, in the chair.

There was an attendance of some seventy members. The Hon. Secretary read the minutes of the Inaugural Meeting, which were confirmed.

The Hon. Secretary read extracts from the minutes of the Council and Committees.

The Hon. Secretary announced the election of the following gentlemen as Associates:—

Mr. W. Graham, Barr.-at-law, Bar Library, High Court, Calcutta.

Mr. S. C. Davidson, c/o Messrs. Davidson & Co., Lall Bazar, Calcutta.

The President announced that the Government of India had sanctioned a grant of Rs. 500 to be given as a prize for the best paper accepted for publication in the Transactions each year.

The President exhibited a boulder found in a coal-seam at Sanctoria, and read the following paper on the occurrence:—

Note on a Boulder found embedded in a Coal-seam, Raniganj Coalfield, Bengal.

BY

T. H. Holland, F.R.S.

The boulder exhibited was obtained by Mr. H. H. Macleod, Superintendent of the Bengal Coal Company, and was found embedded in the Sibpur coal-seam, north district of No. 2 pit, Damudarpur Colliery, near Charanpur, Raniganj Coalfield. At this point the Sibpur seam is 12 to 14 feet thick under a cover of 180-200 feet.

The boulder is ellipsoidal in shape, its three diameters measuring $9\frac{3}{4}'' \times 8\frac{3}{4}'' \times 4\frac{3}{4}''$. It weighs just 23 lbs. and has a specific gravity of 2·62. Its perfect rounding is of a kind commonly seen in some of the conglomerates of the Damuda series.

No records appear to have been made before of similar occurrences in India, but numerous cases have been noticed in England, Germany, Austria, and the United States. In 1885 Dr. Stur published a paper in the *Jahrbuch der geol. Reichsanstalt*[1] of Austria, summarising previous records of stones found in coal-seams, and describing some new occurrences in Austria. Stur states that the earliest record of the kind that he could find was published by John Phillips in the 1855 edition of his Manual of Geology, concerning a boulder found in coal near Newcastle, and another at Norbury near Stockport.[2] Stur overlooked the fact, however,

[1] Stur. Ueber die in Flötzen reiner Steinkohle enthaltenen Stein-Rundmassen und Torf-Sphärosiderite. *Jahrb. der k. k. geol. Reichs.*, XXXV., 1885, 613.

[2] Phillips. "Manual of Geology," 1853, p. 220. This is presumably the reference given by Stur as p. 225.

that this record was preceded by two papers read before the Literary and Philosophical Society of Manchester by E. W. Binney. In his first paper on "The Origin of Coal," read in 1846,[1] Binney, in referring to the Lancashire Coal-field, states that in two seams of coal, namely, the four feet mine at Patricroft, and a small seam under it at Pendleton, he obtained "rounded stones of several pounds in weight; but as both these specimens came from the neighbourhood of great faults," he states that "they may have been brought to the places where they were found, by other causes than currents of running water. They, however, are interesting, and very difficult to account for, being well rounded. Their composition is the same, though found in different seams and distant places, being of hard crystalline quartz, more resembling Gannister than any other stone in the carboniferous series. The outsides of both stones are well coated with a covering of coal, showing that they must have lain long in the places where they were found."

In his subsequent search for accounts of similar boulders in coal-seams, Mr. Binney found mention of one which had been discovered on the 4th November, 1850, in the Rhydgaled Colliery, near Mold. From the analysis and description given, this Welsh stone was evidently a quartzite or sandstone also; it was found in the Bone Coal ten inches from the top of the seam, and was completely embedded in the coal. Having made apparently careful enquiries, without success, regarding similar occurrences, Mr. Binney concluded that the phenomenon was rare, and he forthwith discussed the origin of the three stones. After bringing together several observations by Darwin and Lyell to show the transporting power of tree-roots and seaweed, by which

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1 *Mem. Lit. and Phil. Socy. of Manch.*, 2nd series, Vol. VIII., p. 166.

fragments of foreign rocks of various sorts have been stranded on coral islands in the Pacific, Mr. Binney concluded that this explanation was inapplicable to the conditions under which the coal was formed, but as the stones presented certain outward resemblances to aërolites, he considered them to be of meteoric origin, having fallen when the coal was in the soft state.[1] It is, however, practically certain that the three stones described by Binney were sandstones or quartzites, having no real resemblance to any meteorites in composition.

The record of previous cases of the kind given by Stur also omits reference to the boulders found in the Lancashire coal-seams described by J. Plant[2] and by W. J. Grimshaw[3] in 1878.

During the year in which Stur published the paper above referred to (1885), W. S. Gresley described the occurrence of five quartzite boulders in the "Lount Nether" coal, Coleorton Colliery, Leicestershire. The boulders were all enveloped in coal about 20 inches from the top of the seam, 375′ from the surface.[4] They were all well rounded and the largest weighed $11\frac{1}{2}$ lbs. Mr. Gresley remarks that "the coal-seam in this colliery was particularly subject to 'horses' or 'wants,' that is, sudden interruptions in the continuity of the coal, its place being taken by sandstone and shale, exhibiting current bedding, and often enclosing patches of detrital coal. The coal-bed is here and there swelled up to double its ordinary thickness, and again, hard by, is reduced to half its normal thickness." He

1 E. W. Binney. "On some Supposed Meteorites found in Seams of Coal." *Mem. Lit. and Phil. Socy. of Manchester*, 2nd series, Vol. IX., 306-320.

2 *Trans. Manch. Geol. Soc.*, XIII., 141.

3 *Ibid.*, XIV., 373.

4 *Geol. Mag.*, 1885, 553.

concludes that the boulders were dropped or washed out of the roots of trees as they were floated along in flood-time from higher ground on which they grew.

Mr. Gresley cites some other instances of boulders, either embedded in the coal-seams or in the "measures" enclosing the coal. One of these found in Shropshire was a pebble of lead-ore, interesting in showing that the lead-ore was formed prior to the deposition of the coal, for the ore probably, though not certainly, came from the veins in the carboniferous limestones. Another was found at Church Gresley Colliery in Derbyshire, measuring 10″ × 6″, and five small pebbles all in the underclay. Some of the cases cited by Mr. Gresley are not, however, exactly parallel to the instance under consideration. For example, the pebbles found in the South Wales coalfields are, apparently, occurrences of conglomerates in which pebbles of coal are mixed with those of other rocks.[1]

The occurrence he refers to in the North Staffordshire Coalfield is also not quite clear. From the report of a British Association Committee published in 1865 (p. 43), it appears that "instances have come under notice of the occurrence of large rounded quartz pebbles in shales and ironstones, lying near the base of the upper thick measures at Apedale; and in another case a large siliceous water-worn boulder, some pounds in weight, was met with at considerable depth near a fault in one of the pits of the Cheadle Coalfield." The Committee does not discuss the origin of these pebbles or describe precisely their mode of occurrence, their investigations being directed to the distribution of organic remains in the coalfields.

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1 *Cf.* J. Buddle, *Trans. Geol. Socy.*, 2nd series, Vol. VI., 215, 1842; W. E. Logan, *loc. cit.*, p. 491; and H. T. De la Beche, *Mem. Geol. Surv.*, Vol. I., p. 193.

Since the publication of Dr. Stur's and Mr. Gresley's papers, other instances have been recorded for the Lancashire Coalfield by J. Radcliffe [1] and J. Spencer,[2] both in 1887.

From the discussion following the first of these two papers, it is evident that the occurrence of boulders in coal-seams has been frequently noticed. Various theories have been framed to account for such boulders: they have been regarded as blocks dropped by icebergs, the explanation often offered for the pebbles found in the chalk and carboniferous limestone; they have been described as meteorites, and even as bombs ejected from the volcanoes of the moon. But the explanation satisfactory to most occurrences is that which supposes the pebbles to be dropped by floating tree-roots. The transport of rounded pebbles entangled in tree-roots has been quite commonly observed, and Mr. Gresley's evidence as to the occurrence of these boulders in the vicinity of "wants" and "wash-outs" supports this conclusion. It does not necessarily follow that the pebbles have been brought directly by trees, the places in which they were originally rounded, as for instance at the foot of a large mountain range; for the trees may have been growing on or near an older conglomerate, and in the case of our Talchir boulder-beds might even have picked up glaciated pebbles and have dropped them in an adjacent coal-forming marsh during times of flood. The occurrence, therefore, of a glaciated pebble in a coal-seam would not necessarily indicate that it was dropped by floating ice upon the area in which coal was forming. The action of floating tree-roots seems to be best in agreement with the observed facts, for it is possible that the coal-producing marsh lands were often overwhelmed by floods, and by local oscillations of

[1] *Quart. Journ. Geol. Soc.*, XLIII., 599, 1887. [2] *Ibid.*, XLIII., 734.

level subjected to temporary erosion such as that shown by the "wants." The object of this note is to draw attention to the occurrence of these boulders in coal-seams, and to invite the record of precise details regarding their mode of occurrence: it appears that they are often thoughtlessly put aside as accidents of no importance.

Mr. G. H. Gough (Damudarpur Colliery) said he was sorry the information about the boulder was so indefinite. All that was known was that the boulder was found somewhere in the seam, but the miner who had discovered it had since left the district. Several other smaller boulders had been found at various times. Instructions had been given to the mine officials to report the finding of any similar boulders, and any information so obtained would be communicated to the members.

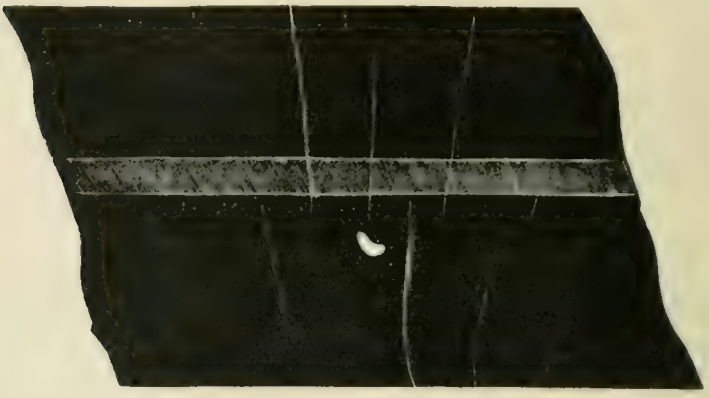
Mr. Ward (Giridih) said that he would like to insist on the desirability and importance of recording, when a boulder is found in a coal-seam, exactly (1) the position in the coal-seam (whether at the top or bottom, or at some intermediate position); and (2) the angle at which the boulder lies. The latter point is of no little importance in connection with the theory, which the President has advanced in his very interesting paper, as to the mode of occurrence of the boulder exhibited. The natural position which a boulder, sinking through liquid, or semi-liquid, material, would assume, would be that of the boulder now on the table. Supposing, however, it sank in material offering greater resistance, it would very likely be found to be tilted at some other angle and possibly be found end up. In that case the President's theory would be confirmed.

The fact—which he believes has nowhere been recorded—that the remains, in great numbers, of very large trees,

lying on the top of the lower seam, or rather in the layers of sandstone forming the roof of the coal-seam, were found in No. 25 mine, Serampore Colliery in the Giridih Coalfield, may be adduced as corroborative evidence of the correctness of the theory advanced by the President. The remains referred to were those of trees 50 to 70 feet in length. They lay in various parts of the mine, crossing each other at all angles, and infrequently (perhaps never) offering opportunities of measuring the whole length. Each tree was represented by a layer of very bright coaly matter, from $\frac{3}{4}$″ to a mere film in thickness, and tapering in breadth from 9″ or 10″, to 2″ or 3″. The whole of these remains may be said to have occupied not more than the first 12″ or 15″ of the sandstone immediately overlying the coal. In connection with the President's remarks these trees are of interest because their size would indicate that their transporting power was very great. A boulder entangled in the roots of such a tree could be carried a long way by water.

Mr. E. C. Agabeg (Gaurangdi) mentioned the case of a similar boulder being found in one of his mines, and subsequently wrote that, so far as he could remember, it was between 1897-98 that a quartzite boulder (pear-shaped) was found embedded in the Gaurangdi seam, a section of which is shewn on p. 146. A careful watch was kept on all headings, but without any further find. The boulder weighed about 3 lbs. and had a thin covering of pyrites.

The seam in which it was found is in the Barakar, or Lower Damuda series, and is the fourth seam in the measures, overlying the Talchirs.



Section of Gourangdi Seam.

Scale 10′ = 1″ Inch.

REFERENCES.

COAL

GREY STONE

QUARTZITE BOULDER.

Mr. W. MacFarlane's paper on "the Barakar Iron and Steel Works" was read as follows:—

Barakar Iron Works.

BY

Mr. W. McFarlane.

These works were originally started in 1875 by the Barakar Iron Works Company, but after many vicissitudes were closed in 1879. A few years later Government took over the plant then existing, and after making some additions the works were re-started. They were carried on by Government for about $8\frac{1}{2}$ years when they were purchased by the present Company. That was in 1889. Very little of the works as they then stood now remain.

The plant then consisted of two small open top furnaces —one only being worked—for which the blast was heated by coal in pipe stoves. One blowing engine with its complement of boilers which were entirely fired by coal. The production of pig iron in 1889-90 was 9,000 tons per annum. This was mainly disposed of to Government establishments either as pig iron or in the shape of castings.

The foundries then covered an area of about 12,300 sq. feet and the production was 3,800 tons per annum.

No collieries were then connected with the Works, all the fuel required either in the shape of coal or coke being purchased.

When the works were taken over by this Company, an immediate start was made to remodel the furnace plant. One new furnace (No. 3) was built on modern lines and three 17' diam. Cowper stoves for heating the blast. The other two furnaces were remodelled and converted into close-top to enable the furnace gas to be utilized in firing the boilers.

These furnaces have, however, been since removed and replaced with furnaces Nos. 1 and 2 as you have seen them to-day.

Additional Cowper stoves but of larger size, *viz.*, 21′, diam. and 65′ high, have been added from time to time, and 10 stoves are now erected, while the foundations for another have been put down, which will be erected later.

The foundations for a fourth furnace have also been put down, and this is intended to be proceeded with so soon as a disposal of the output can be seen. This furnace has been designed in order to be able to smelt Manganese-ore for the production of Ferro-manganese.

The blowing plant was also added to by the two Barclay engines working to-day, and the old engine, which was on the ground when the works were taken over from Government, has been removed, and replaced by a Galloway Engine of 750 H.P., and as you have seen, we are now putting down a Parson's Turbo Blowing Engine of the latest type which will run at 3,500 revolutions per minute and develop 750 H.P.

This engine will have 5 boilers working at 150 lbs. pressure delivering steam to it. Three sets of Green's Economiser have been put down in connection with the boiler plants.

The two furnaces now on blast produce over 10,000 tons per week, and when 3 furnaces are running, the production will be 50 % more.

The arrangements for removal of slag are materially different to-day from what they were 16 years ago. Then the slag tubs were all hand-hauled to the tip while to-day the slag is removed by locos in ladles—taking 7 and 13 tons —in a molten state and poured on the tip while liquid.

The furnaces are not of the same height or capacity as those at home generally, but in this we are governed by

local conditions, of which the principal factor is the nature of the fuel obtainable. From the nature of the coal generally, but largely from the method of coking, the coke has not the strength to stand the pressure of heavier burdens in the furnace; it would crush before reaching the melting zone, and therefore be blown as dust into the gas mains in even larger quantities than you have seen to-day coming from one of the stoves after only 24 hours' working.

This is an important point to the mining industry and it is still more important to the iron manufacturers. Indian cokes carry an abnormal quantity of ash as compared with coke used by home iron-makers, and leads to an abnormal consumption of flux in such works, militating against higher outturn of iron per furnace and materially affecting economy in production and life of a furnace. There is distinctly room for enterprise in the production of better grade coke, —an enterprise which would be remunerative not only for supplies to such works but in ordinary foundry requirements generally.

The coke we receive varies in ash contents from 20—26 °/₀.

In the foundry department the area covered by the shops has been increased to 104,000 sq. feet. Two new pipe foundries—one with hydraulic equipment and one with electric equipment—have been erected with machine shops in connection, for turning out vertically cast pipes expeditiously and equal in all respects to home production.

One shop 457 feet by 78 feet long is laid out for sleeper and chair work, and another 290 feet by 79 feet in length for general work.

The foundry department has a productive capacity of 25,000 to 30,000 tons per annum and the outturn comprises sleepers and chairs, fencing material, columns for

building, 6. 1. pipes and specials, telegraph posts, etc., and all classes of general work.

The consumption of coke in this department alone runs from 6,000-7,500 tons per annum.

There were 6 cupolas in this department, when the works were taken over from Government, and there are now 14.

An extension in this department is under consideration by putting down a new General Foundry in order to do heavy castings up to 10 tons.

In addition we have machine shops and blacksmiths and erecting yards for carrying out new and repair work in connection with furnaces and other departments.

The steel works are of course quite new. The furnaces, which are of the Siemens Martin type, have a productive capacity of 20,000 tons per annum and are provided with a Wellman Seaver Charging Machine for charging materials into the furnaces ; these furnaces, also the reheating furnaces, being, of course, gas-fired from a battery of 7 producers.

In the Rolling Mills, we have a 28″ mill driven by horizontal reversing engine with 37½″ cylinders and 54″ stroke for cogging ingots down to blooms for small mill, or finishing into joists or rails. This mill has its complement of live rolls both on cogging and finishing sides, patent tilters for turning over the ingots, hydraulic shears, saw, etc.

At the small mill, which is a 14″ 3 high bar and guide mill driven by horizontal tandem engine with 18″ and 28″ diam. cylinders and 36″ stroke, ordinary merchant sections are finished.

Outside the main shop are straightening, punching and shearing machines, etc., and in connection with the roll-turning shop a 15 ton 3-motor electric crane has been erected for handling the heavy rolls when required to be changed or turned up.

The power employed in the steel works is steam, hydraulic, and electric. In the electric power house we have two 250 H.P. Dynamos capable of giving an output of 175 Kilowatts each. Terminal voltage 220. This power being utilized for charging machine, roll-turning lathe, overhead crane, live roll gearing, hot saws finishing machine, etc., also for lighting the works at night.

Hydraulic power at pressure of 750 lbs. per sq. inch operates the melting shop hoist, furnace doors, and valves, 28″ mill engine clutch gear, mechanical tilters, shears, hot saws transverse motion, pillar cranes for handling blooms, etc.

For calcining Dolomite for the hearths of melting furnaces, a cupola 42′ high has been erected with an electrically driven blower.

The Company has its own colliery for coal supplies, but not yet for coke supplies, although that is in contemplation with a view to improving the quality for better furnace working.

Our iron-ore workings also cover a considerable area situated in various parts of the country.

From first to last the Company has spent over Rs. 70,00,000 on these works, and will continue to extend as trade requirements justify.

The development of iron manufacture in India has not been without many vicissitudes—tragic as well as humorous.

The first works started were in 1853 by the Indian Steel Chrome and Iron Company but closed in 1859. In 1855 a small furnace was started at Birbhoom which made $2\frac{1}{2}$ tons per day, but this was stopped owing to the difficulty in getting fuel charcoal supplies; an attempt was, however, made in 1875 to restart the works but it also proved unsuccessful.

In 1857 the Kumaon Iron Works were started but were

closed in 1864. In this case the iron-ore and charcoal had to be transported long distances over mountain paths by mules and goats, and in the rains the roads disappeared, also the ore and fuel.

In 1860 works were put down at Burwal, Central India, but on the day the furnace was blown in, it cracked and threatened to wreck the tent in which the inauguration banquet was being held by the burning fuel, so that the engines had to be stopped. No more money was forthcoming to rebuild it and the works closed.

In 1875 a furnace was started at Warora which worked for 6 days in all.

In 1880 the Raja of Sermur Nahan erected a charcoal blast furnace on the top of a mountain near his residence, and after getting the blowing engine, boilers and other materials dragged up the mountain and erected, the furnace never was started. All the material, ore, etc., had to be carried 14 miles by mule and there was no water.

Iron works were also started in Burma by King Theebaw, but as an accident to His Majesty's palanquin happened one day by which he was hurt, the Burmese priests persuaded His Majesty that it was a warning of the God's displeasure at the erection of the works near the sacred Pagoda, and the works stopped.

Not many years ago there was a proposal to start iron works near Calcutta, in which it was proposed to bring the ore from Salem and to use sea-shells as a flux. We use over 50,000 tons per annum of flux for the furnaces: to gather sea-shells to that extent would be somewhat of an undertaking.

Most of these attempts to start iron works failed because of the sites being badly chosen for convenient supplies of raw material and fuel.

In this paper I have referred in a general way and briefly to the salient points of the undertaking. I have not attempted to go into details as that would have taken up too much of your time to-day when other papers of more interest to you are to be given.

The undertaking has had its ups and downs, but the iron industry has been thoroughly established, although the same thing cannot be said of the steel. We have had considerable difficulties to contend with—external as well as internal—in that department, the most adverse being the competition with foreign "dumped" steel. With such competition the prospects for steel working in India are not encouraging.

Mr. L. L. Fermor read a paper, entitled "The Manganese-ore Deposits of India,"[1] the discussion of which was adjourned until the next meeting.

A paper by Mr. J. White, entitled "Waste in Indian Mining," was, in the absence of the writer, left over to a future meeting.

The Hon. Secretary proposed the following resolution :—

"The members of the Mining and Geological Institute of India, in General Meeting assembled, desire to place on record their great grief at the terrible calamity which has fallen upon the Courrières Collieries, France, where more than 1,100 valuable lives were lost. They wish to express their deep sympathy with the bereaved relatives, and with the surviving miners of Courrières, and the owners of the colliery."

The resolution was passed in silence, the members standing.

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[1] This paper appeared in Vol. I., pt. 2, of the "Transactions."

Previous to the meeting the members inspected the Barakar Iron and Steel Works, under the guidance of the General Manager, Mr. W. MacFarlane, and his chief assistant, Mr. F. L. Schwenk. The various processes in the manufacture of iron and steel were clearly explained. The works are equipped with the most modern machinery; two blast-furnaces are now in blast, and a third is being built. Employment is given to more than 10,000 hands.

After the meeting the members were entertained at breakfast by the Bengal Iron and Steel Company, Limited.

Account of General Meeting.

Held at Giridih, November 30th, 1906.

The Honorary Secretary (Mr. W. H. Pickering) regretted the absence of the President, and proposed that Mr. T. H. Ward should take the chair. A letter of apology from Mr. T. H. Holland was read.

Mr. Ward delivered his opening address, and gave a description of the plant that members would see later in the day.

The Honorary Secretary then read the minutes of the last meeting, which were confirmed, and gave extracts from the minutes of the Council meeting.

Mr. Ward read papers on the following subjects :—

"Self-acting Inclines."
"A Rapid Cage-changing Contrivance."
"Solid Cope-cappings."
"The Internal Examination of Wire Ropes."

Messrs. Holland and Ward's paper on the "Geology of the Giridih Coalfield" was also read.

Maps, plans, etc., and a pair of solid cone rope-cappings were exhibited in connection with the above papers.

Owing to the time taken in the reading and discussion of the above papers, the other papers on the agenda were postponed until the Annual General Meeting to be held in Calcutta at the end of January. These were "Waste in Bengal Coal Mining," by Mr. J. White, and "Premature Explosions of Gunpowder," by Mr. J. Grundy. The Honorary Secretary observed that Mr. White's paper would most

fittingly be read in Calcutta, dealing as it did with commercial questions as well as with mining problems. The discussion of Mr. Fermor's paper on "Manganese in India" was also postponed.

After breakfast the members were conducted round the collieries by Mr. Ward, the Superintendent, and Messrs. Lathbury, Leach, and Wright, Managers. An account of the machinery and equipment inspected by the parties is given in Mr. Ward's opening address, which was read as follows :—

Excursion Meeting of the Institute at Giridih, November 30th, 1906.

OPENING ADDRESS BY T. H. WARD.

I have much pleasure in welcoming the members of the Mining and Geological Institute of India to see my Collieries. This welcome is none the less sincere because I opposed the idea of a visit at this time. I desired to defer the visit until I could shew the Institute more modern methods of handling coal after it has been banked. As plant to effect this is in process of erection, and also the first battery of By-product Ovens erected in India, I felt that I could have given the Institute a more interesting, and, for the younger generation, a more educational visit, in say 6 months' time. My representations to this effect were, however, overridden by the rest of the Council, where I found myself in the unenviable position of representing a minority numbering one You may, however, as I commenced by saying, believe that you are heartily welcome, and that I, and what is of more importance my staff, will do our utmost to make your visit instructive and pleasant. I have, with the assistance of my officers, drawn up a succinct description of the places named in the programme.

I feel sure that you will all recognize the difficulties so unexpectedly large a number of visitors imposes on my staff, if we are to succeed in shewing every individual all that is down in the programme. We have carefully worked out a plan which we believe will meet the difficulties. The carrying out of that plan, however, depends entirely on the hearty co-operation of members. We must first of all find out from

you how many are going underground (No. 2 Party of the programme). Both parties will then be divided into sections, each section will have a number and a leader assigned to it. Individual members of each section are asked to follow implicitly that leader, and render him prompt obedience.

Each section will be led to a different part of the plant. One will go straight to the air lock, another to the boilers, another to the engine, another to the winding engines, etc., etc. In this way, but in a different order, each section and each individual will see everything there is to see, and hear a description of what is shewn. The same procedure will be followed in inspecting the fall of coal—about 1,000 tons—which will be brought about for the edification of members. It is of the first importance that the sections going underground should co-operate with the leaders, or serious delay will be caused. In this case after all have witnessed the internal examination of the winding rope—$4\frac{1}{2}$" circumference—the first section will descend the mine. The second section will inspect the winding engines and then descend. The third section will see the "Rapid cage-changing contrivance," then the winding engines, and then descend the mine. Underground, the first section will, after inspecting the pit-bottom, visit the electric pump at No. 2 Central pit underground—it delivers 200 gallons a minute against a head of 500 feet—while the next section is being assembled at the pit-bottom. By the time the first section has inspected the pump the next section will be ready to pass into the engine house, and so on with succeeding sections. The next point visited will be No. 1 Central pit-bottom and the main self-acting incline on that side. This incline is 800 feet in length, and sets of 10 tubs are run down. The arrangement is described in a subsequent note in the "Transactions." The section will then proceed to inspect the "side-of-work" in which

the fall is to be brought about. They will be taken in to see the undergoing and the timbering. As each successive section must see the place before the Overman commences to draw the timber off, an unavoidable delay will occur here, and all are asked to co-operate in getting through as quickly as possible, and in patiently awaiting the next event. The operation of drawing off the timber, and breaking down the "spurns," will not take much less than an hour. It is proposed to utilize this interval by shewing the self-acting incline at work. Members will then be warned that the fuses are being lit, and in a few minutes the first section will be able to go in to see the fall, and will then pass on and return by nearly the same route to the No. 2 Central pit-bottom, inspecting the stables en route. The first, second and other sections will then ascend, and complete their inspection of the surface plant while the remaining sections are being brought to bank.

DESCRIPTION OF PLACES VISITED AT THE EAST INDIAN RAILWAY COLLIERIES.

No. 1—Patrodih Mine.

This shaft is 300 feet deep, to the Kurhurbari Lower seam, which is being opened out, and is 16 feet in diameter. It was sunk to provide ventilation for the whole of the Serampore Colliery which comprises the unworked area of the coalfield to the east of the Baniadih-Komaljore dolerite dyke. At present Nos. 1 and 2 Central pits and 16A tap this area, and the Deep pit, which will work out the coal up to the dyke, has been commenced.

A Walker's "Indestructible" Fan, 24 feet in diameter, and 8 feet in width, has been installed. It is fitted with Walker's anti-vibration shutter, and has an inlet 10 feet in

diameter on each side, the discharge being through an expanding chimney.

The fan is actuated by a pair of compound condensing engines, the cylinders having the following dimensions :—

High pressure—20″ diameter
Low ,, 36″ ,,

both with a stroke of 4 feet.

To provide for accidents, besides the compound condensing combination, the fan can be actuated by either cylinder singly—high pressure steam being admitted to the low pressure cylinder for this purpose—exhausting direct to the atmosphere or condensing.

The full combination is designed to produce 400,000 cubic feet of air against 3 inch water gauge = 190 H.P.

The output of the fan at the present time is 150,000 cubic feet at 1·90 inches water gauge = 45 H.P. only. It requires 70 revolutions of the fan to produce this quantity at the stated water gauge.

The fan is driven by 11 cotton ropes, $1\frac{3}{4}$ inches in diameter, the driving wheel being 18 feet, and the driven wheel 9 feet in diameter, respectively.

A similar unit is working at the Jubilee pit on the Kurhurbaree side.

Steam is provided by three full-sized Lancashire boilers, 100 lbs. pressure. The boiler shed, 40 feet span, is in course of erection. The brick chimney is 133′ 9″ above flue level, and is nowhere less than 5 feet in the clear. The section is octagonal inside and out.

The shaft is fitted with apparatus for winding coal and water. The water-raising side is permanently cased in at the top, and the cage side suitably "bonnetted." Later on a duplex type pump will be installed in the pit, and both cages will be used for raising coal.

The winding engine is direct acting—a pair of 14″ cylinders 18″ stroke, drum 5 feet diameter. Ropes $2\frac{3}{4}$″ circumference, cage single tub. The speed attained is satisfactory. These cylinders, and they are in excellent condition, have a wonderful record. They drove a goods locomotive in 1850, and were, when they were transferred to the Collieries in about 1885, used to drive an underground pumping engine with two 12″ horizontally fixed rams, with a lift of 270 feet. They were then used for years as a geared (second motion) winding engine, and were last year converted to their present use.

The fan engine-house, pit-bank, and winding engine house, are lighted by electricity, and arrangements are being made to light the pit-bottom.

The ventilating plant and shaft cost about Rs. 1,20,000. The fan itself cost Rs. 52,000, and was first turned round in November last year.

No. 2—Central Pit.

This shaft (as also No. 1 Central, 800 feet away on the strike) is an ellipse 12 ft. by 15 ft, and is 450 feet in depth, from the bank to the Kurhurbari Lower seam, which is here 22 ft. in thickness.

Double-decked cages, carrying 2 tubs tandem on each deck, running on wire guides, are fitted, and the bank is double to allow of the simultaneous caging of the tubs on both decks. Similar arrangements are being made underground, but the arrangements are yet in a very incomplete state, and await the completion of the direct loading and screening plant now being erected. The wire guides are carried over pullies on the pit-head frame and brought back below the bank, where each (the return lengths being utilized as guides for the cage gates) is kept taut by a dead weight

of 3 tons. The cages can be changed in a few minutes (see the writer's paper on "A Rapid Cage Changing Arrangement") for water tanks, having a capacity of 2 tons of water, and the pit bottom is so arranged that this can be done without any change being made there.

The top bank is 25 feet above ground level, and the pit-head frame (built by Messrs. Burn and Company of Howrah, from Messrs. Walker Brothers' plans) is 50 feet from the bank to the centre of the pullies. These are of English manufacture, 12 feet in diameter. The direct acting winding engines are by the Lilleshall Company, Shropshire, the principal dimensions and particulars being :—

Cylinders—pair 24 inches diam. by $4\frac{1}{2}$ ft. stroke.
Drum—15 ft. diam.—wood lagging fitted with steam and foot brakes.
Ropes—$4\frac{1}{2}$ inches circumference.
Load—net coal 2 tons.
„ water 2 tons.

Steam for these engines, and the electrical installation here, is provided by 3 full-sized Lancashire boilers, with an Edgemoor miltitubular boiler of 100 H.P. in reserve. The chimney is of the same size as that at No. 1 Patrodih described above. A double acting 6" Cameron pump supplies the feed water. The boiler shed has a span of 40 feet, and is so designed that any boiler can be withdrawn. The coal bunkers will, when the screening plant is finished, be supplied by tipping-tubs travelling on a gantry.

The pit-bank, engine house, wharves, and pit-bottom, are lighted by electricity, which is also supplied from this centre to the mines.

The Power House contains 2 Westinghouse direct-current generators, one driven by a Buckeye engine, having an

output of 100 Kilowatts, at 250 volts (400 Amperes); and the other, driven by a Rushton and Proctor vertical engine, 9½ inch cylinder by 10 inch stroke, gives an output of 22½ Kilowatts at 125 volts (180 Amperes). The latter is used entirely for lighting the pit banks and pit-bottoms, engine house, and sidings, at Nos. 1 and 2 Central pits, and the Colliery Manager's office. The former is now driving a Hayward and Tyler three throw pump, fixed near the pit-bottom, absorbing 145 Amperes; and will soon in addition be driving a hauling engine, which is being built in the workshops; and a centrifugal pump which is also under construction at the workshops. These it is expected will absorb 140 amperes, leaving a balance of power which will be used to drive the motor actuating the screening plant. The Power Plant described above (both units) will be done away with, and the whole of the Electric Power required on the Serampore and Kurhurbari Colliery provided by the utilisation of the waste gases from the by-product Plant.

The three-throw pump was originally driven through gear wheels. The vibration has proved to be excessive, and has led to several serious break-downs. The motor has now been arranged to drive the pump by a belt.

The hauling engine referred to will be actuated by two of the motors from the condemned Jeffrey coal-cutting plant. This machine, which is fitted with 2 drums 3½ feet in diameter, and the centrifugal pumping engine, which will be actuated by one of the Jeffrey motors, will enable the dip driving towards the Deep pit to be pushed on, without waiting for the plant which it will ultimately be necessary to obtain from Europe. One thousand three hundred feet of the total 4,000 has already been driven.

The supplementing of the electric power, at this important centre, will be arranged in connection with the utilization

of the surplus gas from the by-product coke ovens now being erected, where, in 12 months' time, all the electric power required for hauling, pumping and lighting, in the Serampore and Kurhurbari Collieries, will be generated. The writer hopes, in 12 months' time, to see electric locomotives underground in the Central pits Nos. 1 and 2, and in No. 16A mine, entirely substituting the large stable of horses now working in those mines.

A brief description of the screening plant now being erected may be of interest to visitors.

The tubs, which will make the round trip back to the shaft by gravity assisted in one place by a creeper, will be tipped by mechanically driven, "run through" tipplers—one for each bank—and the coal will run on to a 4-feet wide Koch's steel belt, 50 feet in length, where stone and shale will be picked out. It will then be delivered on to the main jigger, where steam coal, rubble, and slack will be separated. The steam coal will find its way on to a 3-feet wide Koch's steel belt, 18 feet in length, where a special variety of steam coal for the mail service of the railway will be picked off, the coal passing on to a "ladder," on which it will be lowered into wagons passing on the outer of the 3 lines of $5\frac{1}{2}$ feet gauge railway which passes under the screening bank.

The rubble coal will either rejoin the steam on the 3-feet belt, or run direct into wagons passing on the middle line of rails.

The slack will fall on to a second jigger, and will be separated into smithy and dust (fine for the coke ovens). The smithy will be carried up by a creeper, and can be (1) dropped into a hopper, and loaded direct into wagons passing on the middle line of railway, or (2) dropped into tubs for the boiler bunkers, or (3) allowed to rejoin the steam coal. The "fine" passes up a creeper into a bunker over the third, or

inner line of railway, and can be dropped direct into wagons. The process of separating the slack can be omitted, and this class loaded direct into wagons or into the tipping tubs for the boiler bunkers.

The tipping and screening plant will be operated by a 35 H.P. direct-current motor. The plant is capable of dealing with 100 tons per hour and will cost, with the double bank, about Rs. 18,000. The screening plant has been made by Messrs. Head Wrightson and Company of Stockton-on-Tees, and the double bank in the Colliery workshops.

In the course of the next six months I hope to obtain sanction for three more screening plants similar in design.

I regret that this plant cannot be shewn in operation, and that the members of the Institute will have to see the present method of handling the coal. The tubs are run into the old-fashioned end tipplers, and the coal slides down great chutes on to the ground. It is picked up (the separation into steam and slack being made by hand) and carried in baskets up to the level of the wharf (bottom of the wagon) and dumped down inside from the height of the loader's head.

No. 2 party will visit the underground workings, and will see the method of working the thick coal which has had such notable results on output and cost. The writer has, in years gone by, as Manager of the Serampore Colliery, where the system has been developed, been urged to relinquish it on the score of its danger and doubtful utility. Members will be able to judge for themselves on both these points.

The Colliery Manager, Mr. G. C. Lathbury, has prepared a plan which will enable members clearly to follow the application of the system in the particular case they are to see.

As is generally known now, the system is a development

of that followed in working the South Staffordshire thick coal (30 feet). There—and this constitutes one of the two chief differences in the two cases [the other being the much worse roof (black-batt) in South Staffordshire]—the coal is split up into 10 or 11 layers of coal by bands of argillaceous shale, which is softer than the coal, and therefore forms divisions, or, as it is colloquially called in South Staffordshire, "partings." In the 22 feet coal at Serampore (and this remark is applicable to all Gondwana coals), there are no "partings" at all. Any bands in the coal seam are of shale or sandstone, and are always harder than the coal itself. Generally speaking, indeed, the coal has to be broken or chipped from these hard bands; so that, instead of being "partings," they serve an opposite purpose, and cause the seam of coal to be stronger and more difficult to break up. In South Staffordshire the seam of coal is attacked from the bottom, and the lowest layer (the "Benches") is first removed, say $2\frac{1}{2}$ to 3 feet in thickness, then the next higher, and so on, until the layers are out of reach, and have to be cut in, overhand, by men working on planks, hung by chains from a ladder at one end and a scaffold pole (a prop) at the other; or by a "byatt" (putlog) at one end.

In the Serampore mines the bottom $5\frac{1}{2}$ feet is removed, and rooms 40 feet by 40 feet formed by drivings round the limits. Cross drivings form 4 or 6 pillars. The drivings are first driven 6 feet in width and are then widened out to 10 or 12 feet, and timbered by props, leaving the superincumbent coal on "knobs," or small pillars. The coal is cut off from the sides, and from the "rib" if it is a "side-of-work" being newly opened out, or from the "man-of-war" (South Staffordshire colloquial) or "chowkidar" (Indian colloquial) if "gob" or "goaf" forms the back, by narrow drivings right up to the roof. The floors of these drivings form ties,

helping to steady the mass while the opening out work is being done, and must be almost wholly removed before the coal will come away.

The final operation, after "gelding" down the knobs to the lowest limit, and drawing the timber, is to blow them out, causing the coal to fall $5\frac{1}{2}$ feet. In falling it breaks up, so that it only remains to load it out. Obviously, only the loading rate has to be paid on it.

The rails are carried right into these openings, in that matter following exactly South Staffordshire practice. In the past it has been contended that it is safer to carry the coal out, and load it outside the opening, and this seems to be the view which a "Thin-mine" man naturally takes. No "Thick-coal" man would assent to this proposition. The former contends that the loaders do not have to remain so long in the opening, under the newly uncovered roof, when the loading is done back from the bolt hole. He forgets that the actual act of loading the coal into the tub takes no appreciable time, that more people must be employed to load the same quantity in the same time to make up for the increased labour of carrying, and that therefore more people are actually passing to and fro under the roof, than would be the case if the loading were done in the opening directly alongside the fall. It is obvious that the work cannot be done in the same time, and that the danger is accentuated because the longer the opening stands the more likely it is to "weight." It is the safer plan to take the rails right into the openings, and get the fall loaded up in the shortest time, by the fewest number of people. That this is the cheaper plan is also obvious.

Deep Pit.

This shaft is being sunk, and is now about 230 feet in depth. It has the same form as No. 2 Central pit, *viz.*, an

ellipse 12 ft. by 15 ft. We expect to intersect the Lower seam at from 850 feet to 900 feet.

Later on a paper, describing this sinking in detail, will be submitted, so that a very brief account is all that is necessary here.

The permanent pit-head frame by Messrs. Walker Brothers, Wigan, 50 feet in height, on foundations 25 feet in height, has been erected, and the permanent winding engine, a facsimile of the engine at No. 2 Central pit, has been installed, and has just commenced to run. A sinking engine, a pair of 12-inch cylinders geared to a 6-foot drum (old plant), has been put down for sinking, and both engines will now be available. Arrangements have been made to use wire guides in continuing the sinking, so that winding at full speed and with both engines at the same time will be safe. The use of wire guides necessitates almost (at any rate it is the most convenient plan) the use of doors to cover the pit top. The design of these presents some novel features.

I regret that we are not able to shew the Institute the wire guides in use. Mr. Lathbury, the Colliery Manager, has worked early and late to accomplish this. The work is, however, far enough advanced for members to follow the details. The plan is usual in England, but has never been attempted in this country. The counterbalancing of the doors has been specially designed by me so that the doors can be adopted by a Colliery Manager who has no machine shop to fall back on, and has to rely on a blacksmith. Mr. Grundy has taken a special interest in this design, and has never tired of carrying a heavy model about to shew to mining men. The doors are certainly safer as well as cheaper to handle, than the clumsy trolly, or "bridge," now universally in use in the Bengal Coalfields. I shall be glad to do anything I can to facilitate the use of this contrivance,

and with that object in view will supply a copy of the plan of the instalment at the Deep pit to anyone desiring to adopt the method. Mr. Grundy's model will also be available, and later on the paper I purpose writing for our "Transactions," in which full details of its application to the Deep pit sinking will of course be shewn.

The sinking is ventilated by 15" diameter Sirocco fan, driven by a 9" single cylinder by 16" stroke horizontal engine. The air-pipes in the shaft are 15 inch in diameter.

There are 2 full-sized Lancashire boilers, 120 lbs. steam pressure, installed, and the foundations for a third are ready. The chimney is of the same size and type as those at No. 2 Central and No. 1 Patrodih. It was completed, and brought into use a few months ago.

A pit, 6 feet in diameter, has been sunk about 70 feet to the N. W. of the shaft, and will be continued down to the horizon of the Bhadooah upper seam (the Bhadooah main seam has died out in this part of the coalfield) at a depth of 200 feet, intersecting the 11 seams of coal which occur in the upper measures. The water from these seams will be pumped at this pit, electric pumps being installed for the purpose, which will be actuated by current generated by the surplus gas from the by-product ovens now being erected about 2,250 feet away. The water pumped will be all used in these by-product works, and is a most valuable asset.

Unloading and Storing of Ropes.

Ropes are delivered from England coiled on drums containing 5 to 6,000, and sometimes 10 000 feet, and weighing as a maximum about 7 tons. Until recently they were unloaded by coolies working with levers of various kinds, packing, etc. The uncoiling of the rope presented serious

difficulties, when the coil was a heavy one, and much expense for labour.

They are now handled by an overhead crane capable of lifting 7 tons. An axle, which is part of a specially designed trolly (of which there are ten, so that the several sizes of rope and partly used coils can be dealt with), is passed through the drum which is swung up, and traversed by the crane, until it is clear of the railway wagon and over the wharf which has been constructed to facilitate this operation. Running alongside the rope shed for its whole length up to the wharf and right under the crane, is a line of railway 5′ 4″ gauge. On this runs a trolly, or traverser, carrying, at right angles to the 5′ 4″ railway, rails laid to a gauge of 6′ 5″, on which one of the 10 rope-trollies referred to above runs. The axle, carrying the drum and ropecoil, is lowered into its bearings, and the traverser pushed along, about 150 feet, on a gentle down grade, until the rope trolly is opposite one of the 10 sidings inside the shed. The rope trolly is then run off the traverser into the shed, and remains there until the coil of rope, which can be easily run off, has been used up. A heavy coil can be handled out of the wagon, and placed in the shed, by 3 or 4 coolies in an hour or so. The cost of handling is therefore very small, and the chances of damage to the rope are entirely obviated.

Workshops at Baniadih.

These are in a compound 280 feet by 250 feet, surrounded by a wall 12 feet in height. This compound has been enlarged this year from 127 feet by 250 feet, and a second entrance arranged. Both entrances give access to the Metre Gauge Railway. The blacksmith's shop, 150 feet in length by 36 feet by 20 feet to the wall-plate, was built in 1904, and replaced one 200 feet by 15 feet by 6′ 6″ to the

wall-plate. A carpenter's shop, 40 feet by 86 feet by 16½ feet to the bottom of the roof trusses, is in course of erection and replaces a structure 40 feet long by 15 feet wide by 5′ 6″ to the wall-plate. The new shop will have a "saw-toothed" roof, the vertical glazed sides facing the north. One of the girders for this roof has been built and tested and will be seen in position.

This year also a long-idle saw-bench has been got to work, driven by a very fine 30 H.P. automatic expansion steam engine. The arrangement is temporary, as the shops will, in a few months when current is available from the by-product plant, be "electrified."

The machinery has been added to in the last 2 years by the addition of the following plant:—

Lathe, screw cutting and surfacing, 8″ centres.

Planing machine.

Slotting machine, 10″ stroke.

Saw-sharpening machine for circular and pit saws.

Emery grinder with attachment for grinding twist drills.

Overhead 7-ton crane for lifting locos.

The machine shop is driven by a 16″ cylinder by 30″ stroke engine working high pressure, non-expansively and without a governor. Steam is provided by 2 small Lancashire boilers. This plant (engine and boilers) will be scrapped when electricity is applied.

The machine and fitting shops has a "pucca" concrete roof and is badly lighted. It is intended to remedy this later on.

The party will be shewn:—

(1) A steel wire rope being spliced by the men who have been trained during the last 6 months.

(2) The electric hauling engines referred to in the description of No. 2 Central pit.

(3) The water barrel which has been devised by the writer for sinking pits, and which is believed to be a great advance on Galloway's system. (This barrel is awaiting parts from Jamalpur.)

(4) Arrangements for setting up a cupola for melting cast iron.

(5) A $5\frac{3}{4}$" steel rope being spliced.

The Internal Examination of Wire Ropes.

BY

Thos. H. Ward.

In a paper under the title "Internal Corrosion of Wire Ropes," read before the Chesterfield and Midland Counties Institution of Mechanical Engineers in 1897, and published in the "Transactions of the Federated Institution of Mining Engineers," Vol. XIV, Part 3, the author (Mr. Thos. G. Lees) states:—

"Should the ropes be working in a wet shaft, the water of which "contains anything of a corrosive nature, it has become generally "acknowledged by engineers who have had such waters to deal with, "that oil or grease, however carefully applied, will not keep the ropes "from being corroded, and that the water will find its way, after a "time, to the inside and do serious damage to the wires, while to all "outward appearance the rope may be in good order. This appa- "rently safe condition of the rope on the outside has been the means of "frequently deceiving the person making the inspection, and the "writer is afraid that, unless steps are taken to get at the root of the "evil, accidents from internal corrosion of wire ropes will continue to "occur in the future."

"It is quite impossible, by any of the usual systems of outward "inspection such as are practised at many collieries, to discover the "condition of the rope internally, and it does not appear reasonable "to simply rely upon such superficial examinations as passing the rope "daily through the hands. This method may indicate whether there "are any broken wires on the outside, but cannot reveal the condi- "tion of the inside of the rope."

The same author quotes Mr. A. H. Stokes, H. M. Inspector of Mines for the Midland District, as having made the following remarks, in the discussion of a paper read by

Mr. P. M. Chester, before the same Institute, on "Colliery Winding Ropes and their Attachments":—

"Then the author (Mr. Chester) made a remark that ropes "'were best made with hempen centres only.'...He (Mr. Stokes) "held in his hand a specimen of Lang's patent rope, a very strong "rope for the work it had to do, yet the hempen core had so absorbed "moisture, that the inside of the rope was so corroded that it broke "whilst at work! He was not at liberty to mention where, but the "manager was a gentleman who would not put any but the best "material on. It broke a few yards from the cap, and the cage "went to the bottom. The outward appearance of the rope was such "as to deceive all who examined it, being very little worn, in fact it "was difficult to detect any signs of wear, yet the inside of the rope "was eaten away by corrosion to such an extent that it broke "whilst winding. The rope had only been at work about 18 months "in a dry shaft, and had been well and frequently greased. The cause "of failure was certainly corrosion.

In the discussion on Mr. Thos. G. Lees' paper, above quoted, Mr A. H. Stokes remarked:—

"He had investigated a great many cases of broken winding-"ropes, but he did not remember ever finding one that had "broken by being worn out. No engine-wright would certify that a "rope was in good order if there were a large number of broken "wires or appreciable wearing."

"Breakages were generally due to internal corrosion, which "could not be seen nor detected, and the question was suggested as "to how long the rope should remain in use."

Mr. Robert McLaren, H. M. Inspector of Mines for East Scotland, remarks in his report for 1905:—

"The examination of the rope at best is only external, as the "person making the examination is guided solely by what he observes "on the outside, and he may consider, and he cannot be blamed, that "so long as there are no broken wires the rope is quite good and "perfectly safe. Whereas by internal corrosion it may be in an "unsafe condition.

The terrible accident at Aldwarke Main Colliery,

Rotherham, in which 7 men lost their lives by the breaking of the rope while they were descending the mine, during the time Mr. W. H. Pickering was Chief Inspector of the Yorkshire and Lincolnshire District, described in the report for that District for 1904, is of great interest. Mr. Pickering stated in his evidence that the rope had been weakened to less than one-third of its strength by internal corrosion, and that "some of the internal wires were pointed at the ends." The evidence of the official who had examined the rope a few hours before the accident was that "he found nothing wrong." It seems highly probable that this accident —the one involving the loss of the greatest number of lives in that district that year—would have been easily avoided if the rope had been examined internally.

In the case about to be described, the cause of the failure was only too evident, but was not discoverable from the ordinary external examination, on which, as the above quotations shew, we have up to now relied all the world over.

The rope which failed was in use at 16A Mine, Serampur Colliery. It was a $3\frac{1}{2}$ inch circumference plough steel rope, and had been in use for 1 year, 5 months and 20 days, when it broke on the 1st June this year. It was the "overlap" rope. It had undergone the usual weekly examination, by the Colliery Enginewright, on the previous day, and the usual daily examination in the morning. Not a single broken wire had been found. (Broken wires are reported in writing at once and a record kept). The rope broke at 17.30 o'clock when two full tubs were being raised (total load of cage and tubs 45 cwts). It parted on the engine side of the pulley, when the cage was about 100 feet from the pit bottom, and 245 feet from the bank Two hundred and eighty feet of rope fell back with the cage.

On the pit bank and in the pit bottom a good many

pieces of wire, 6 to 8 inches in length, were found. Examination of these shewed that, at the point at which the "lay" brought each wire in contact with the hemp core of the rope, it had been either completely, or nearly, corroded away. On testing by bending, it was found that the material near the corroded ends of these wires was very brittle, but that in the middle of the length, which was as the abraded surface shewed, in every case the part which the "lay" brought to the outside of the rope, the material was as tough and good as it ever was.

It is certain that these pieces were incapable of taking up any strain, and that many were, perhaps, separate, and held in position by neighbouring wires. When the strain was suddenly released, these pieces were flirted out in all directions. An examination of that portion of the rope which fell down the pit shewed that this was what happened at every place where the rope was suddenly flexed, as it struck the bottom, for at these points the corroded wires broke, and the ends were left sticking out.

The rope was in the hands of long-experienced officials, with a splendid record for care and skill behind them. There was, as has been already stated, not a single broken wire from end to end of the rope, so far as an external examination could reveal. After the accident it was found, by untwisting the strands, and by forcibly opening the rope out in various places, that there was extensive corrosion from end to end; that all the wires in the rope—it had 6 strands of 19 wires each, a combination which the writer does not consider advisable—were corroded; that many were nearly eaten through; and that all were rotten at the points of contact with the core. It may be mentioned here that a great deal of the hemp core was also rotten, and could be rubbed to powder between the finger and thumb.

Such an unparalleled position shewed clearly that, unless the ropes in use in this shaft could be examined internally, their safe condition could not be assured. The writer had never heard of the internal examination of a rope, but decided to examine the other running rope at once. The method adopted, and described below, is exceedingly simple, and can be applied by any mechanic to ropes up to $4\frac{1}{2}$ inches in circumference (the largest rope in use in the E.I.R. Collieries) without the least fear of injuring the rope in any way.

Two clamps were made as illustrated in Figure 1 below. These were clamped to the rope, which was first served with a tight wrapping of spunyarn, at a distance of 9 feet apart. (The distance first fixed on was 6 feet, but a trial shewed that 9 feet was a more suitable length for this size of rope). The clamps were rotated, in reverse directions, so as to release the strain on the strands. The clamps were rotated alternately through a semi-revolution, a total of one to one and a half turns each being sufficient to cause the rope to slack out so that a splicer's needle, or a flat-shaped tool,

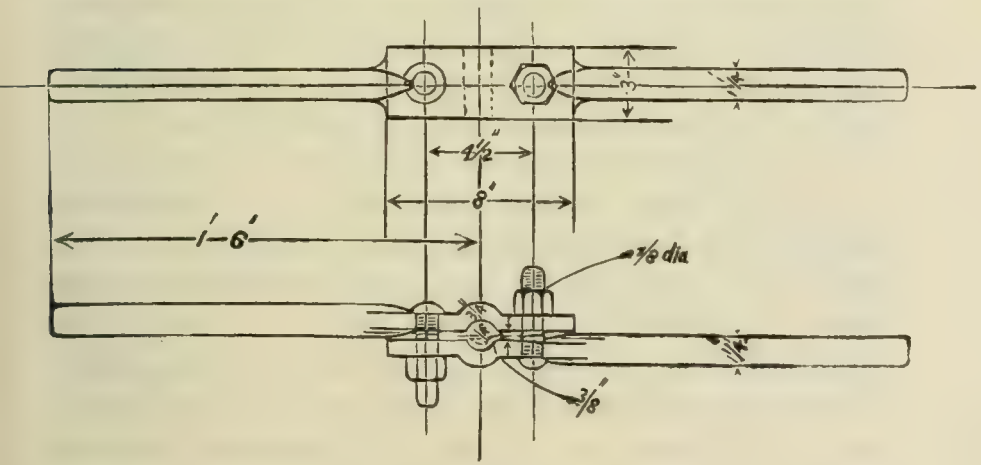

FIG. 1.

Scale :—1½" = 1 foot.

could be introduced under a strand without the least difficulty, rendering internal inspection of the wires in contact with the core perfectly easy in any part of the length between the clamps.

After the inspection had been completed the clamps were rotated in the same careful manner, a semi-revolution alternately, so as to close the rope evenly, and were then removed. It was impossible to detect the slightest difference in the appearance of the part examined, and it was decided that such an operation was in no way injurious to the rope, and that it might be carried out at as many points as would ensure a thoroughly sound opinion being formed as to the internal condition of the rope.

In the case in question the rope was examined in four places in the course of half an hour, and it was clearly ascertained that very slight corrosion had taken place. It was decided, with the utmost confidence, that this rope could be allowed to run.

Orders were passed that in four weeks' time an internal examination was to be again made. This has since been done, with the result that the rope was (on the 15th July) condemned. This rope had only run since the 21st January this year, and was therefore about six months in use.

The writer's staff are now carrying out internal examinations of ropes at all the mines, and it is a satisfactory feature of the situation that, instead of shattered nerves, the outcome of the terrifying experience above described has been an accession of confidence. There is no longer any guess work when passing a rope as safe. All the enginewrights are provided with the necessary, and very simple, apparatus required, and in from 15 to 30 minutes they can examine internally any of their ropes at any point they may select.

In the above described operations on a $3\frac{1}{2}$ inch rope a complete revolution of each clamp (with 9 feet to 10 feet of rope between them) was amply sufficient for the purpose in view. Actual experiment shewed that the clamps could be rotated through double this distance, *i.e.*, through two complete revolutions each, without doing any injury to the rope. Care should of course be taken not to carry rotation any further than is necessary to effect the purpose in view—a slight slackening of the strain on the strands.

If internal corrosion has taken place, rotation, contrary to the lay, will at once fracture the wires. If, with reasonable rotation the wires break it may be accepted as a proof that they have deteriorated. The surviving portions of the broken $3\frac{1}{2}$ inch rope, described above, will not stand rotation at all. Rotation, through a comparatively small angle, ruptures the wires.

The largest ropes in use on these Collieries are, as already stated, $4\frac{1}{2}$ inches in circumference. There are two combinations: one 6/7 (6 strands of 7 wires each) and one 6/8/7 (6 strands, each strand of 8 wires, with a core of 7 wires). The latter rope is the more flexible, and has been found to be very serviceable. There is not only no difficulty in examining the inner sides of the 6 strands in this combination, but the strands themselves are easily opened, and the inner 7 wires examined. The 6/7 combination, in the case of a $4\frac{1}{2}$ inch rope, forms an exceedingly stiff rope presenting a much greater resistance to rotation contrary to the lay. They have, however, been successfully opened and examined. It has been found that a clamp with a larger surface is more suitable for these ropes. See Figure 2 on next page.

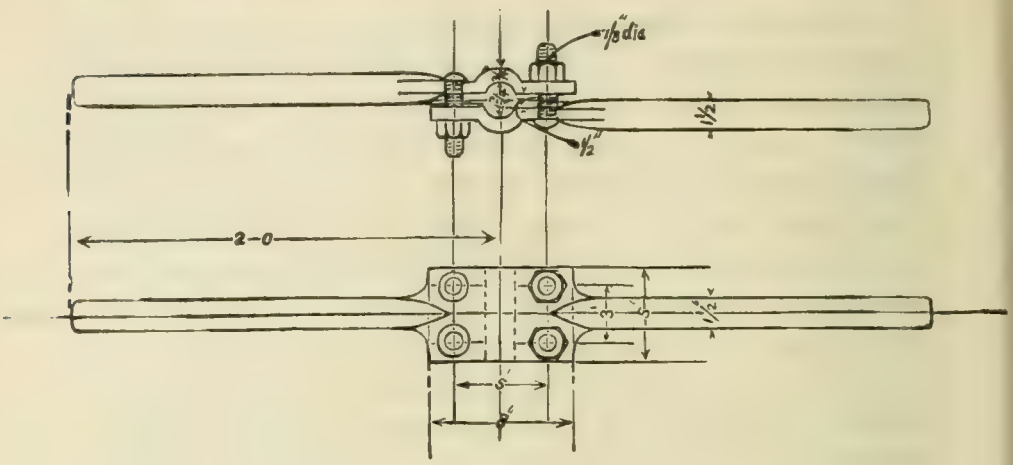

Fig. 2.

Scale:—1½" = 1 foot.

This method can be applied most easily by slacking out the rope until it rests on the ground, or the bank, between the drum and the pit. A distance of only 30 feet from the drum to the first clamp has been found ample in the case of a 4½ inch rope. By paying the rope down the pit, and lashing it at the level of the pit bank, or at the top of the pit-head frame, any point can be examined in the same way.

The writer has no doubt that the system could, with suitable modification of appliances and power, be applied to 6-inch circumference ropes.

In addressing a meeting of Mining Engineers there is no need to emphasize the great advantages of carrying out internal, as well as external, examination of ropes, and the writer feels sure that the plan described will have wide application, and that its adoption will contribute to the safety of the operations which are our daily concern.

Discussion.

The Internal Examination of Wire Ropes.

Mr. C. H. McCabe said there was nothing of more importance in mining demanding the keenest and most serious consideration and care of Engineers as do wire-ropes used for winding ; and the new method for examining a rope internally now brought before members by Mr. Ward, to whom they must feel indebted for his very valuable paper, should receive the closest investigation and inquiry, so that the members should be well informed of its feasibility and the advisability of its universal adoption, to ascertain the internal condition of wire ropes with immunity, and thus avert the repeated terrible loss of life and limb caused by the breakage of ropes which have by the usual external examinations falsely indicated the rope to be absolutely safe and sound and in good working condition.

There was one point which Mr. Ward did not seem to have touched upon, *i.e.*, his experience of previous ropes in the self-same shaft, and whether the ropes referred to in his paper were of the same make and size of previous ropes used, and also the life of previous ropes. And it would also be interesting to know for how long the ropes in question had been in stock prior to their being put on for use, and whether the ropes had been brought direct from England.

He himself (Mr. McCabe) was inclined to think that the continual internal examination of wire-ropes would prove detrimental, as it is a known fact that each time a wire rope is rotated reverse to its lay, it reduces in ductility

and elasticity and becomes more brittle, and, in addition, there is a possibility of the strands not absolutely closing to their original construction or lays, and thus enhancing the chance of internal corrosion as the water or moisture more rapidly finds its way to the hemp core, which is probably the chief reservoir for moisture in a rope, and the core being continually kept in a saturated state very rapidly corrodes the wires in contact. Even if only one portion of the rope is loose in the strands or wires, the moisture finds its way more rapidly to the core which absorbs this moisture and by virtue of capillary attraction the whole length of the hemp core becomes saturated and in turn corrodes the wires.

A good plan from which a very good idea can be formed of what is going on internally in a wire-rope is to cut a short length of the rope near the cap end, and re-cap, say every three months. He had found this to be of great assistance in deciding whether or not the rope should be changed, and by this way the position of the rope on the pulley, and the capping, which are the points where ropes generally show first signs of weakness and corrosion, would be changed every three months, and while making this suggestion perhaps Mr. Ward would let us know whether the ropes in question had been periodically re-capped, and whether or not, after the accident, the ropes had been cut near the cap, and if so, what was their condition at this point.

He was one of those who had the pleasure of watching the rope internally examined on the 30th November, at Serampore Colliery, and admitted that the examination was very rapidly carried out, and one of the demerits of this method would appear to be that, at the point where the clamps had been bolted, the wires of the strands which

received the greatest pressure next the clamps, were somewhat opened and did not, after the examination, close to their original position. It might be possible to eliminate this serious effect by substituting good hard wooden clamps, as wood, being softer than iron, will give somewhat with the wires when pressure is applied to the bolts to tighten the clamps. And the portion examined internally, about 5 to 6 inches in length, into which the splicing needle had been forced, did not fall so close as it was previous to its being examined.

This method evidently gave a wide field for experiment for the chief rope manufacturers, and it would be interesting and of paramount importance to the members of this Institute to have their views on the matter.

Mr. W. H. Pickering said members were greatly obliged to Mr. Ward for his admirable paper. It was practical, and described what was, in his opinion, a new departure in the examination of wire-ropes. This was a most important subject, and interesting to all engineers, for the wire rope had now superseded all other ropes in most engineering operations. It was, however, of the greatest interest to mining engineers, for in mining, valuable life and property hung day after day on the winding ropes. In England there are pits over 2,000 feet in which 30 or 40 men are raised at one time at a velocity in mid-shaft of over 40 miles an hour. Though such express conditions do not exist in India, pits will become deeper every year, and apart from humanity, it was essential that the winding should be as safe as possible, for in the event of a series of serious shaft accidents the labourer would be shy of going down deep shafts.

Anyone who has been responsible for the wire ropes

at collieries, cannot have failed to realise how very unsatisfactory the external examination must necessarily be. By a simple but ingenious contrivance, Mr. Ward appeared to have solved an important problem. He (Mr. Pickering) had seen the examination made, and the contrivance was worked by native labour. There seemed to be ample evidence that the system was a most valuable one, and could be applied to any wire-rope other than lock-coil ropes.

Perhaps the following would be an ideal examination of wire-ropes :—

(1) The daily external examination and report as at present practised.

(2) An internal examination every month by Mr. Ward's contrivance.

(3) An examination every six months by Mr. Ward's contrivance, when the rope should be recapped and a short length cut off. This length to be untwisted and carefully examined. A full report of the whole examination to be made by the engine-wright or some other skilled and qualified person.

It would be, however, a mistake to embody such suggestions in hard and fast rules, or even to come to a definite and final conclusion until the system has had a long and voluntary trial at a large number of places, but he threw them out for consideration and criticism.

Mr. Keelan enquired about the core preservative, and asked if it could have caused the deterioration.

Mr. G. H. Graves asked if the rope could be lubricated internally when opened for examination. It appeared to him that in opening out the rope it would be unwise to

untwist to a greater degree than half a turn or at most a turn.

Mr. J. J. Turnbull asked Mr. Ward if the daily and weekly examination of the ropes was made by Native or European engine-wrights, and what was the usual life of the rope which had broken. Mr. Ward had stated that his staff were carrying out internal examinations of the ropes at all the mines, and he (Mr. Turnbull) would be glad to learn if many other ropes had been found defective or if such were only confined to the particular shaft where the accident occurred ; was the shaft an upcast or downcast, and if the former was a furnace in use there ? Also, had any tests been made to prove that the ropes were in no way injured by the internal examination described in the paper ?

Mr. Griffiths said that in view of the fact that wire ropes are built so that each wire takes its due proportion of the strain, the operation of opening out the rope would, in his opinion, cause undue disturbance of the distribution of strain.

Mr. F. L. G. Simpson asked if similar corrosion had taken place in ropes with wire cores.

Mr. J. Grundy said that some rope-makers in England specially prepared the cores of their ropes with a mixture of graphite and suitable grease, and believed that it is of great use in lessening internal friction as well as safeguarding it against water.

He suggested that the rapid deterioration of the second rope after it had been opened up, might be due to the facility with which water would find its way into the interior of the rope after opening if the strands closed again

less completely. He considered that the question of the particular parts of a rope to be examined was of first-rate importance, as for instance, the part that is on the pulley when the rope takes hold of the cage, the parts likely to be most exposed to water. At many collieries in Lancashire it was customary for the person making a report of the condition of a rope to detail the exact position of any broken wires there might be, and that helped the manager to determine the state of the rope when a mere statement that there were so many broken wires would be misleading.

Mr. Ambler said that at the discussion on the rapid corrosion of the wire-rope exhibited, the information eliminated several possible causes of deterioration, which narrowed the scope of enquiry—acid in solution, or fumes from combustion below were absent, certain facts were then established.

1. That the average life of ropes at this particular pit had been 18 months or three times that of the one exhibited.

2. That after 4 months' use, when the first internal examination was made, nothing wrong was disclosed. But at a second examination only two months later, corrosion had, in that short time, developed to such an extent as to cause it to be rejected as unsafe.

3. It was stated that if the outer pellicle of the wires was removed by acids or other causes, corrosion of the rest was very rapid ; in this instance, therefore,the pellicle must have been in some way destroyed, before such rapid corrosion set up ; and if we eliminate acids as the cause, there remains only mechanical force to have effected this injury of the pellicle ; and taking into consideration the fact that the extensive corrosion commenced from the

time the examination was made, it seems clearly to show that forcing the strands back on themselves, against the lay of the rope, must have fractured this pellicle, and so started the corrosion. It may be asked what agents were present to start and continue the corrosion from this point, though this is hardly pertinent when the fact of extreme corrosion was evident.

He wished, however, to say a few words on the subject : " The corrosion is most marked where the wires are in contact with the tarred core " : this tar contained a certain quantity of free acid, as might be expected, when it was remembered that both Pyroligneous Acid and Tar are the products of the same destructive distillation of wood ; the quantity of acid present, however, was not answerable for all the damage done. Water is an active, though intermediary, agent in the corrosion of iron and steel : it is the oxidising agent—bright metal is at once coated with a film of oxide when in contact with water, this actually forming a protecting coat or film against further corrosion ; unless the film should be destroyed or dissolved by acid or mechanical means, and this latter is present in the wire rope in the friction set up between the wires during the transition of the rope from repose and relaxation to that of tension, and again when relaxing after work.

One reason for the more rapid corrosion after the outer pellicle has been broken, is the increased surface exposed to oxidation by the partial scales and cracks on it.

He thought the corrosion of the hemp core was due to the known action of iron oxide on vegetable fibre, better known as " iron mould, " of which a familiar example is shewn in the yellowish-brown patches too often seen on shirts when brought back by the Dhoby, and which later are found in holes where this has appeared.

There would be little doubt that the strain exerted for the internal examination must injure the wires, and it was equally certain that such examinations, often repeated as suggested, would do more to impair its efficiency and life than twice the amount of wear and tear.

The acid present in the tarred rope might be neutralised by its immersion in caustic lime or other alkalies, and he was of the opinion that if the ropes were occasionally run through such a solution, this would penetrate to the core and check internal corrosion. A beautiful illustration of this shews itself in Sir William Thompson's deep-sea sounding apparatus, this thin bright steel wire to which the lead is attached, in spite of repeated immersions in sea water, retaining its surface unoxidised by being kept when not in use in a bath of caustic alkali.

Zinc in a less degree (when in contact with iron or steel) has a protective influence, which lasts until it is itself converted into oxide. Its protective action is due to its stronger affinity for oxygen than the iron or steel.

Galvinised wire instead of the bright steel was suggested : this would protect from corrosion so long as the metalic zinc coating lasted. But there were many grave objections to its use, the strength of the wire being greatly reduced by the process of zincing (erroneously called galvanising). The wires were stretched and passed through a bath of molten zinc. This has an affinity for iron, in fact this affinity is so strong that were the iron allowed to remain immersed, it would entirely dissolve it. In the process of drawing the wire through the bath a certain quantity is dissolved irregularly, and as the strength of a chain cable is that of its weakest link, the same applies when from any cause any portion of the wire has been unduly reduced in strength.

Mr. Ambler subsequently wrote that it had occurred to him to make a further suggestion for retarding the corrosion of wire ropes.

If the ropes were passed through a vat of oil and afterwards through a caustic lime solution, an insoluble lime soap would be formed in the interstices of the wire, which would be both a preservative against corrosion and a lubricant at the same time. If the solutions were hot the saponifying would be more readily effected.

Mr. D. White also spoke.

Mr. T. H. Ward, replying to the discussion in detail, said it was impracticable to internally examine a rope throughout, but attention should be directed to those parts of a rope which were most liable to deterioration, and to any parts which might be suspected from their external condition. It was difficult to say what parts of a rope were most liable to corrosion. In the case of the broken rope described, the greatest corrosion was no doubt where it broke ; but he would be inclined to think that usually it was near the other (cage) end of the rope —perhaps at the point where it was flexed over the pulley when the cage was on the legs. This seemed to be the generally received opinion, but he was unable to point to any direct evidence on the point. Ropes were not necessarily condemned for broken wires, unless the fractured ends were close together. The ropes at these Collieries were examined daily by native mistries, called in the Special Rules " fitters-in-charge, " also weekly, by the native engine-wrights acting under General Rule *2g* ; but, if anything suspicious was noticed, the Colliery Manager made an examination. The engine-wrights had power to condemn ropes, and their decision on this point was never questioned. No difference

had been noticed in the condition of ropes dependent on their running in upcast or downcast shafts. It should be clearly understood that a good many ropes had been cut from the same coil (4,000 feet in length) as that from which the rope which broke was cut, for other shafts, and have behaved in every respect normally, and shewn no signs of internal corrosion after working for a longer time than the ropes at 16A. One shaft, in which two of these ropes worked, is an upcast, into which the exhaust from a special pump is allowed to escape, and was about 100 feet deeper than 16A. In the latter, though there are two steam pipe ranges, the pumps are fitted with condensers and very little steam escapes. In 16A shaft the other conditions are not very good. The pulleys and drum are 5 feet only in diameter, and it was necessary to use a friction pulley to deflect one of the ropes. No specified time for the internal examination of a rope has yet been laid down, but at 16A the ropes were examined internally weekly, and in several places. The hemp cores of the ropes were not found to be damp. Once corrosion had commenced, and the skin of the wires had been attacked, the ropes appeared to deteriorate very rapidly. The ropes put in place of the broken rope, and of the one condemned on the 15th July, had been found to be corroded, and were about to be changed, after running from the 2nd June and 15th July, or after 181 and 138 days respectively. The suggestion, that the internal examination of these ropes had caused displacement of the strands resulting in admission of water, which had caused the corrosion referred to, seemed to his mind to be entirely disposed of by the consideration that the ropes they displaced had never been examined internally. There was no doubt that, whatever the cause, it was common to both sets of ropes. The

ropes were served with tallow and tar externally as the strands were being replaced. No change took place in the lay of the strands consequent on the opening up of a rope. He and his staff, and they had now had considerable experience of the matter, were quite confident that no injury was sustained by ropes in examining them in the way he had described. He had not tried a rope with a wire core. He had experience of a rope with a single wire core—the wire being of the thickness of the hemp core. This rope gave great trouble, the strands forming bunches at various points, the core evidently taking up the whole strain. It became necessary to cut the core through at distances of 100 feet, leaving gaps with no core in. He had read of similar instances. A wire core would probably behave in much the same way, and he would not care to use such a rope. He had been accused by one speaker of having been reticent in stating the cause of the failure of the rope at 16A. He desired it to be understood that he did not pretend to know the cause of the very rapid and serious corrosion of the ropes in this shaft. To him it was a mystery, and he did not think that any of the suggestions which had been made met the case. Mr. Ambler's remarks were of great interest, and he thought that it might be worth while to investigate the matter on the lines suggested.

The Geology of the Giridih Coalfield.

By T. H. Holland and T. H. Ward.

History of Geological Surveys.

The first systematic geological examination of the Giridih Coalfield was commenced at the end of 1848 by Dr. J. MacClelland,[1] soon after he took charge of the Geological Survey after the death of Mr. Williams. In 1852, Dr. T. Oldham visited the field, and afterwards arranged for the completion of the geological map by Dr. W. L. Willson; but on account of the unsatisfactory nature of the topographical maps, the geological work had to be abandoned until the ground was re-surveyed.

After the completion of this map, Dr. T. W. H. Hughes was deputed in 1868 to revise the previous observations, and to express the new results in the form of a general geological map of the field. Dr. Hughes' results were published in the form of a Memoir by the Geological Survey.[2] Following Dr. Hughes' survey work, Dr. O. Feistmantel examined the fossil plants collected, and described them in various short papers and memoirs.[3]

The next paper of importance was by Dr. W. Saise published by the North of England Institute of Mining

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1 *McClelland.* Report of the Geol. Surv. Ind., for the season 1848-49: Curhurbalee Coalfield, pp. 36-44.

2 *T. W. H. Hughes.* The Kurhurbári Coalfields. *Mem. Geol. Surv. Ind.*, vii, 209-246 (1871).

3 *O. Feistmantel.* Various references in a series of papers on "Some Fossil Floras in India," *Rec. Geol. Sur. Ind.*, ix, 1876, and subsequent volumes. Also *Pal. Indica*, Ser. xii, Vol. iii, 1879, and *Rec. Geol. Surv. Ind.*, xxii, 73, 74, 1889.

Engineers in 1880,[1] and a fuller paper by the same author was published in 1894.[2]

General characters of the field.

The fields covers an area of about 11 square miles, of which 7 square miles only are covered by the coal-bearing Barakar stage. The other parts of the field are occupied by a considerable area of Talchir beds surrounding two small inliers of crystalline rocks in the N.-W. corner of the field, with numerous small exposures of Talchirs along the eastern and southern boundaries. The only Gondwana rocks represented in the field are thus the Talchirs below and the Barakar series resting on them : nothing has been found to correspond to the Ironstone shales or the Raniganj stage in the Jherria and Raniganj fields.

The Talchirs and Barakars.

The succession of beds is apparently perfectly conformable from the Talchirs to the Barakars ; but there is a marked change in lithology at the base of the lower coal seam. Below this seam the strata are mainly shales without coal. Above this line coal-beds occur interstratified with sandstones, amongst which shales take a very subordinate place. It was partly for this reason that Dr. Saise [2] proposed to revert to the nomenclature advocated by Hughes, regarding all below the lower seam as Talchirs and all above as the equivalent of the Barakar series in the other coalfields. Dr. Feistmantel, in 1879, and in 1881,[3] had pointed out that the fossil plants found in the lower parts of the Bara-

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1 *W. Saise.* Kurhûrballee Coalfields, with some remarks on Indian coals. *Trans., N.E. Inst. of M. and M.E.*, xxx, 3-24, 1881.

2 *W. Saise.* The Giridih (Karharbari) Coalfield, with notes on the labour and methods of working coal. *Rec. Geol. Sur. Ind.*, xxvii, 86-100, 1894

3 *O. Feistmantel.* Various references in a series of papers on "Some Fossil Floras in India." *Rec. Geol. Surv. Ind.*, ix, 1876, and subsequent volumes. Also *Pal. Indica*, Ser. xii, Vol. III, 1879, and *Rec. Geol. Sur. Ind.*, xxii, 73, 74, 1889.

kar series in this field had a greater similarity to those found in the Talchirs below than was usually the case in the other coalfields; and he consequently thought that the lower part of the Barakar series in the Giridih field should be grouped with the Talchir series, whilst the upper part might correspond more strictly to the Barakars. Dr. Saise[1] has pointed out that the palæontological conclusion was based on an insufficient amount of evidence, subsequent discoveries of fossil plants having shown that some of the characteristic Barakar species are not so rare in the Karharbari beds as they were originally supposed to be. Dr. Saise has also called attention to the fact that the supposed overlap of the Talchirs by the Barakar series has not been established, as the Talchirs have now been found to exist all over the coalfield. There is no evidence of anything approaching a period of erosion between the Talchirs and the Barakars in this field, and the variations in the thickness of the Talchirs in different parts are no greater than the variations in thickness of many of the sandstone beds lying between the seams of coal. There is, therefore, no reason for separating a special stage or sub-stage of Gondwana rocks under the name of Karharbari, and the strata in the Giridih field thus belong to two stages only —the Talchirs below, and the Barakars resting on them.

Faulted boundaries.

The chief outlines of the field have been determined by the faulting of the Gondwana series down into the crystallines. The northern and southern boundaries are defined by well-marked faults running W.N.W. and E.S.E.; but in

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places at the east and west ends of the field, the boundary line between the Gondwana and the Crystalline rocks appears to be that of original deposition, and unfaulted.

Dyke-rocks.

At the time of Mr. Hughes' survey, there were 15 well-marked dykes of igneous rock recognised in the field. These were divided by him into 3 classes—dioritic traps, felspathic traps, and micaceous traps. These were examined in greater detail in 1895 by Dr. Saise and Mr. Holland.[1] We were able to recognise only two distinct classes of igneous rock intrusive into, and younger than, the Talchirs and Barakar series. One of these forms the large basaltic dykes, corresponding to the dioritic traps of Hughes, and being the dyke-representatives, probably, of the Rajmahal trap-flows of the Upper Gondwana system.

Phosphatic Mica-Peridotites.

The precise nature of the other group of intrusive rocks had remained unsolved for many years on account of the difficulty of obtaining material sufficiently fresh for microscopic examination; but during 1894, Dr. Saise obtained comparatively fresh specimens of this peculiar rock from a thick mass in No. 7 Jogitand shaft, and this gave us the key to their real nature. At about the same time, specimens were obtained from similar dykes in the Raniganj, Jherria and Darjeeling Coalfields, a special study of their characters being described in a paper by Mr. Holland.[2] It was found that these rocks contained large quantities of olivine, together with some other minerals characteristic of the peridotite family; but

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1 *T. H. Holland* and *W. Saise*. On the igneous rocks of the Giridih (Kurhurbaree) Coalfield and their contact effects. *Rec. Geol. Surv. Ind.*, xxviii, 121-138, 1895.

2 *T. H. Holland*. On highly phosphatic Mica-Peridotites intrusive in the Lower Gondwana rocks of Bengal. *Rec. Geol. Surv. Ind.*, xxvii, 129-146. 1894.

the rock was marked off distinctly from all previously known peridotites, and, for that matter, all previously known igneous rocks, by the large quantity of apatite (phosphate of lime), which has been found in some specimens to amount to over 11 per cent. of the total rock. The numerous prisms of apatite had previously been mistaken for felspar, and the rocks had consequently been regarded as forms of ordinary mica-traps. Besides the olivine and the apatite, there occur large quantities of biotite in this rock, and in a hand-specimen the biotite is the most pronounced, often the only mineral that can be recognised readily. Besides its peculiarities of mineral composition, this rock has other strange features: the dykes formed by it are always narrow, seldom amounting to more than 4 or 5 feet thick, but in the mine-workings they are found to ramify amongst the coal into the very thinnest veins, and the rock has also a pernicious habit of spreading along the coal-seams in the form of sheets. Wherever it passes through a coal-seam, the coal is converted into prismatic coke for a distance from the border of the dyke equivalent to the thickness of the dyke itself, and on account of its habits, therefore, this rock has done far more damage to the coal-seams it has traversed than that which has been done by the much larger basaltic intrusions. The other remarkable feature of the mica-peridotite is its persistence throughout the coalfields of Bengal. It has not only been found in those of the Damuda Valley and the Giridih Coalfield, but also in the isolated coalfield of Darjeeling more than 200 miles away. Yet no instance of this rock has been discovered cutting the metamorphic or crystalline areas in this or any other district. Why it should be so common in the Bengal coalfields and not in the older rocks around remains a mystery.

The jadeite is usually milk-white or chrome-green in colour, rarely emerald-green. When of the latter colour it is found under the microscope to be pleochroic, sections parallel to the clinopinacoid ranging from deep emerald-green to clear canary-yellow.

The jadeite is frequently crushed and converted into a mass of thin needles, among which rods of a pale amphibole have been noticed: these are believed to be derived from the jadeite by pressure-metamorphism. Small crystals of orthoclase, twinned according to the Carlsbad law, have been noticed in the emerald-green variety, but, as a rule, inclusions of foreign minerals are extremely rare. A large hand-specimen from Burma consists of a vein of jadeite in a dark greyish-green schistose rock, composed of small prisms of a greenish-grey hornblende, possibly allied to glaucophane.

Examination of specimens of jadeite said to have been found at Ta-li-fu, prove that they are in every respect identical with the mineral from Burma, and the author concludes that the Ta-li-fu specimens were brought by merchants from Tammaw and were not obtained locally, no jadeite being known to occur in Yunnan.

The paper is illustrated by three views of the Tammaw Mines, reproduced from photographs by Dr. Noetling.

H. H. H.

Coal-fields of the Northern Shan States.

1. *The Lashio Coalfield:* by T. D La Touche and R. R. Simpson. Rec., Geol. Surv. India, XXXIII, 117-124.
2. *The Namma, Man-sang and Man-se-le Coalfields:* by R. R. Simpson, *ibid.*, 125-150.

These two papers embody the results of the investigations carried on by Messrs. La Touche and Simpson in the winter of 1904–1905.

The *Lashio Coalfield* is situated in the upper part of the valley of the Nam-yau, a tributary of the Nam-tu river, and is composed of sandy clays and soft sandstones of late Tertiary age, with seams of coal ranging from a few inches to 30 feet in thickness. The quality of the coal is poor, and, unless briquetted, it is apparently unsuited for use in locomotives, and is, therefore unlikely to command more than a small local market.

The *Namma Coalfield* lies in the Hsen-wi and Hsipaw divisions.

and has an area of about 50 square miles. The rocks are soft, clayey shales with coal seams and soft sandstones and conglomerates, all of upper Tertiary age. The coal, although better than that of the other fields in the Northern Shan States, is of poor quality, and, unless briquetted, will be of little value as a locomotive fuel. Only two seams of economic importance have been found; one, a thick seam (7 ft.–17 ft.) east of Namma, and the other at Möng Ting. Owing to the steep dip of the beds, the softness of the enclosing rocks, and the small area above saturation level, mining would be both difficult and expensive.

The *Man-sang Coalfield* is situated in the South Hsenwi division, 16 miles S.S.E. of the Namma field. The known area contains only 13½ square miles. The rocks are similar to those of the other coalfields of the Northern Shan States, but there are also numerous intrusions of dolerite. The largest seam is 4½ feet thick, and the coal a hard shaley lignite of poor quality.

The *Man-se-le Coalfield*, which lies 27 miles to E.S.E. of the Namma field, has an area of 13½ square miles. It is probable that there are not more than one or two seams of importance, the greatest thickness of seam being 4 feet. The field is at present difficult of access, and the coal poor in quality.

H. H. H.

Report of the Judges for the Transvaal Chamber of Mines' Competition for devices and suggestions for the alleviation of Miners' Phthisis.

Transvaal Chamb. Comm., Rep. for 1904, pp. 118-146, Johannesburg (1905).

There were 229 competitors whose devices and suggestions were tabulated as follows:—

(1) Respirators and masks. (2) Dust Extractors and Hoods. (3) Water drills. (4) Jets delivering water inside the hole. (5) Jets delivering water at mouth of hole. (6) Sprays. (7) Atomisers. (8) Medical suggestions. (9) Miscellaneous.

Numbers (1), (2), (8) and (9) were ruled out as impracticable. No. 4, after trial, was rejected as it caused the drill to block, and

Coal-resources of the field.

In 1894, Dr. Saise estimated the gross coal-resources of the Giridih field as follows :—

	Tons.	Tons.
Lower seam	112,836,712	
Upper seam	1,412,600	
Bhaddoah main seam ...	4,083,840	
Other hill seams	5,615,250	
		123,948,402
For the net resources deduct—		
For faults, trap-intrusions, and loss in working of 25% ...	30,997,100	
Output, 1857-1893	9 358 000	
Probably lost in working ...	1,000 000	
		41,355,100
Total available coal in 1894 ...	...	82,593,302

Between December 1893 and December 1905, the output of coal from Giridih was 8,323,198 tons, thus leaving a little over 74 million tons as the estimated stocks at the beginning of 1906. The figures will probably require a certain amount of revision on account of the more precise information obtained by recent work.

NOTES, REVIEWS, AND ABSTRACTS.

Names of Abstractors with their addresses.

(1) Metalliferous Mining generally—L. L. Fermor, Geological Survey of India, Calcutta.

(2) Gold—C. H. Richards, The Crotons, Coromandel P. O., (Mysore).

(3) Coal-mining—Jas. Grundy, Inspector of Mines, Sitarampur, E.I.R.
G. F. Adams, Inspector of Mines, Dhanbaid, E.I.R.
W. T. Griffiths, C. E. College, Sibpur.

(4) Geology—H. H. Hayden, Geological Survey of India, Calcutta.
Guy E. Pilgrim, Geological Survey of India, Calcutta.

(5) Civil Engineering—T. H. Ward, Supdt., E.I.R. Collieries, Giridih, E.I.R.

(6) Electricity—Paul Brühl, C. E. College, Sibpur.

(7) Medicine and Sanitation—R. R. Simpson, Inspector of Mines, Department of Mines, Calcutta.

N.B.—*Cuttings from technical journals, transactions, etc., suitable for publishing in abstract form, may be sent to the above abstractors by members of the Institute.*

Jadeite in Burma.

Weitere Mitteilungen über den Jadeit von Ober-Birma: by MAX BAUER. (Centralolatt für Min., Geol. und Paläontologie, 1906, No. 4, pp. 97-112).

In this paper the author describes specimens of jadeite brought from Burma—presumably from the Tammaw Mines—in the year 1904 by Dr. August Tobler. The mines were visited in 1893 by Dr. F. Noetling, who found the jadeite associated with serpentine, which he regarded as intrusive in the local sedimentary rocks of Tertiary age. Prof. Bauer, however, prefers to regard the jadeite-bearing rocks as members of the crystalline schists, upon which the miocene beds have been deposited.

worm is endemic among the general population in nearly all tropical and sub-tropical countries. It is present among miners in the Westphalian coalfield, in the French and Belgian collieries, and in the Cornish tin-mines.

There are many channels by which *Ankylostoma* might be introduced into British coal-mines. The conditions found underground in these mines are such that the worm would, in many cases, at any rate, probably become firmly established.

In view of the expense and difficulty of eradicating the worm from any mine in which it has become established, it is of the utmost importance that preventive measures should be undertaken without delay. Complete eradication does not yet appear to have been ever accomplished.

The necessary prevention is best accomplished by the provision of proper sanitary accommodation in the main roads underground and at the pits' mouth, by regulations to prevent pollution of the pit by human fæces, and by the establishment of a limited quarantine system for workpeople from infected areas.

R. R. S.

Description of the Sinking of Shafts through sand at Ardur, Ayrshire, by the Pneumatic process, with notes on the subject of Caisson-ventilation and Sickness.

By Thos. H. Mattram, *Trans. Inst. Min. Eng.*, XXX, ii, pp. 205-237 (1905).

After dealing with the engineering problems concerned the writer treats of the serious illness frequently caused by exposure to a highly-compressed atmosphere. He advances the following rules for the guidance of those working under such conditions :—

(1) The workers should be sound and well.

(2) When entering into and returning from the working chamber, the proceeding should be gradually accomplished, the pressure not being increased or decreased more quickly than, say, 4 pounds per minute. In the event of any person, when entering the chamber, suffering pain, which cannot be removed by compressing the nostrils and blowing out the drums of the ears, the pressure should be gradually reduced, and that person sent out of the caisson.

(3) The air should be maintained in a fresh state by distribution, percolation and other means.

(4) As the pressure increases, the length of the workers' shift should decrease.

Re-compression is sometimes resorted to, the patient being allowed to return to the normal pressure gradually, or in about 45 minutes. In extreme cases Dr. E. H. Snell has used morphia, ergot and other drugs hypodermically, and also stimulating liniments containing aconite and belladonna, while relief has been obtained by the application of moderately tight bandages to the painful parts.

R. R. S.

Baths for Coal-miners.

Colliery Guardian, Vol. XC, p. 1045 (1905); Vol. XCI, p. 325 (1906).

The question of the provision of baths for colliers has been attracting considerable attention in the Newcastle coalfield. It has been proposed that buildings might be erected by the owners, who should receive, say, 4% on cost—(*a*) as a separate establishment, (*b*) in connection with the Institute. In the first case an undertaking should be given by the workmen to allow an "offtake" to be made to cover interest and working expenses. In the second case the Institute would be responsible.

Another scheme is that baths should be provided in new houses on householders agreeing to pay reasonable rent for the privilege. At a local colliery institute four baths were erected and opened in 1904. During the first seventy-one weeks in which they were available only one out of twenty-five members per week used the baths. The charge for a bath was two pence, and the revenue obtained was insufficient to pay even the interest on the cost of the buildings.

At Shotton Colliery in South Durham the owners have attached a bath-room to each of 40 new colliery-houses.

R. R. S.

Compressed Air Illness; or Caisson Disease.

Abstract of a lecture at the Royal Inst. of Public Health, by THOS. OLIVER, MA., M.D, etc., *Mining Jour.*, LXXIX, p. 20 (1906).

After a discussion, partly historical, of the use of compressed air in caisson-sinking the writer goes on to describe the symptoms of

caisson-disease. These develop during and after the period of decompression. In the minor form they consist of severe pains in the muscles, and occasionally there is epistanis and bleeding from the nose. In the severer forms the paralysis may persist for months, being accompanied by loss of sensation, and the development of ulcers. Sometimes after leaving the air lock the man staggers and falls, becomes unconscious, with embarassed breathing, dilated pupils, rapid and feeble pulse and cold skin. These symptoms may be ushered in by vertigo or vomiting. Death or temporary mental weakness may ensue; other results being loss of part of the field of vision, diplopia and facial paralysis.

As the result of a series of elaborate experiments the author discards the theory of toxaemia, and concludes that frothing of the blood, or the sudden liberation of gas in the blood vessels is the chief cause of compressed air illness, and that in most cases it is due to the curtailment of the period of decompression. Men who are alcoholics, or who suffer from catarrh, weak heart, or diseased lungs, should not be employed, and frequent medical inspection of the workmen should be enforced. Ventilation of the caisson is most important.

Recompression has come to be the recognized method of treating the disease.

"Mine Sanitation on the Rand."

By D. Macaulay, M.A., M.B., C.M., and Louis G. Irvine, M.A., M.D., B.Sc. (Abstract from the "Mining Journal" of July 7th and 14th, 1906, of a paper read before the Chemical, Metallurgical and Mining Society of South Africa.)

During 1904 and 1905 thirty separate fatal accidents due to "gassing" took place on the Rand. They involved the death of nine whites and 31 natives, and serious consequences to some 24 others. Poisoning by carbon-monoxide accounted for most of the deaths, but a considerable proportion were caused by poisoning by nitrous fumes. The presence of these gases is usually due to the incomplete combustion of explosives, and the serious consequences to which they give rise is primarily due to lack of adequate ventilation.

The writers recommend firstly the adoption of ventilating

machinery with arrangements for "coursing" the air, and secondly, for dead ends, the use of an air jet, which can be used to propel air into the working-place during the shift, and extract it after blasting.

It is to respiratory disease, however, that the principal mortality in metalliferous mining is due, and the three factors which cause this disease are dust, infection, and gaseous impurities. For the prevention of dust the authors recommend the use of a water-drill of the Leyner type, but on the score of expense are more in favour of a device by which a coarse spray is kept playing at the mouth of the drill-hole. For hand-drilling, a wet sponge squeezed against the drill should be employed at the start. To allay the dust caused by blasting probably no better appliance can be used than the James "water-blast," the principle of which is to employ the pressure of the compressed air to project into the face, immediately after blasting, a quantity of water. This not only effectually allays the dust, but dissolves nitrous fumes. The writers believe that the majority of cases of miners' phthisis in the end become tubercular, and they suggest strict examination for tubercular disease of all new employés, with the exclusion from the mine of all those found to be infected. The avoidance of the risk of chills by the provision of change-houses for the miners is another important point. In discussing the objections to water-spraying devices owing to the use of such devices being favourable to the spread of ankylostomiasis, the writers propound the question :—which is the greater risk—dust or the worm? In their opinion, unquestionably dust.

R. R. S.

A Rapid Cage-changing Contrivance.

BY

Thos. H. Ward.

The difficulty and cost of changing heavy cages,—*i.e.*, cages for two or four tubs, and weighing over 2 tons,—and the delay to winding operations, can be entirely avoided by adopting the arrangement shewn in the illustrations. This plan was first devised some years ago, by the writer, to enable a horse box to be put on in place of the cage at No. 1 Central Pit, E.I.R., every week-end. The cage carries two tubs tandem on a single deck, and the horse box can be substituted on a Saturday night in a few minutes (15 to 20) by the banksmen, so that all the horses in the mine can be brought out at a week-end, and put down again on Monday morning, without any expense or delay to output.

In the illustrations (Plate 4) the arrangement adopted at No. 2 Central Pit, East India Railway, is shewn. At this place a double-decked cage (carrying 4 tubs, 2 tandem on each deck), and a water tank (of 2 tons capacity) have to be interchanged. In this case the arrangement is made for both cages. Advantage is taken of the height of the pit-bank above the ground level to do the changing under the bank, thus saving the trouble and expense of raising the cages to the bank level. The bank is a double one, admitting of the simultaneous changing of the tubs on the top and bottom decks, and it would cause serious delay to output to change the cages on it.

It will be seen that a trolly is provided for each cage, the length of which is more than twice the width of the

shaft opening. The trolly is accommodated in sidings, on each side of the pit, in line with the cage, and parallel to the guides (in this case, rope). These sidings may be close to, or at any convenient distance from, the pit shaft, so that the handling of tubs, and banking operations generally, can be carried on, if necessary, between the pit shaft and the trolly. This is the arrangement at No. 1 Central Pit above referred to.

The trolly must always be left with the unloaded half towards the pit, so that it can be pushed over the opening, and form a bridge over it, before the load is placed in position. The operation of changing the water tank for the cage is illustrated on the left-hand side of Plate 4. The unoccupied half (the cage is placed on the other half) of the trolly is pushed over the pit, in this case travelling from the siding on the left, and the tank is lowered on to it; the tackle chains are knocked off, the guide blocks removed, and the trolly traversed until the cage resting on it is over the pit. In this position the tackle chains and guide blocks are again attached. The cage is then raised clear of the trolly, the journey of the latter across the opening is completed, and it is run into the siding on the side of the pit opposite to that it started from.

The cages in question weigh over 2 tons, and are 9′ 6″ long and about 11 feet in height. The change can be effected in from 15 to 20 minutes. The method can of course be used when a cage has to be taken out for repairs. The cage to be substituted is placed on the trolly—an operation which can be greatly facilitated by arranging a wharf-wall alongside the trolly—at the end farthest from the pit, before the commencement of the changing operations.

The trolly shewn in Plate 4 is made of two channel bars $8'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$, suitably connected transversely, and

runs on 5 pairs of tub wheels, spaced so that the clear bearing in any position is not greater than about one-and-a-half times the width of the opening to be bridged.

Solid Rope Cappings.

BY

Thos. H. Ward.

A new system of capping has been strenuously advocated by Mr. Gerrard, His Majesty's Chief Inspector of Mines for the Manchester and Ireland District. In his reports for 1904 and 1905, are given the results of experiments which shew that the capping in universal use has a holding-power of from 42 to 64 per cent. only of the breaking strain of the rope. These are very poor results, and there can be no doubt of the desirability of adopting a better system. The subject is perhaps of greater importance to the collieries under the author's charge, because heavier loads are raised in the two-decked, four-tub cages than elsewhere in this country; but it is becoming of increasing importance to many who are contemplating deeper sinkings, and who must, therefore, adopt apparatus suited to conditions of greater difficulty in raising coal. Nor must it be forgotten that even with lighter loads, if the same safety margin is adopted, the ratio of the holding-power of the capping to the breaking strain of the rope is just the same. The subject is, therefore, of general interest, and no further apology is needed for drawing special attention to the fact, so strongly brought out by the figures published in Mr. Gerrard's report for 1904, that the new solid capping will give the full breaking strain of the rope.

A pair of cappings (shown at the meeting of the Institute at Giridih on the 30th November last), fitted to a 6-feet length of $2\frac{3}{4}''$ circumference rope, were sent to Jamalpur to

be tested to destruction. The result of the test was that the rope broke without injuring the cappings, the fracture being entirely outside. Mr. Gerrard's results are exactly the same (see p. 21 of his report for 1904).

The other exhibit, shown at the meeting at Giridih, was a pair of cappings for $4\frac{1}{2}''$ circumference rope on each end of a 7-feet length of rope. The capping at one end was complete. At the other end the filling had been omitted so that members could see how the wires were prepared. This pair of cappings will be sent to Jamalpur and tested to destruction.[1] There is no doubt that the result will justify the adoption of this system in these collieries, and indeed by Mining Engineers throughout Bengal. The cappings were made in the E.I.R. colliery workshops, by native blacksmiths, without the help of a Power hammer—a convenience which it is hoped will be provided ere long. No doubt if Mining Engineers of Bengal decide to adopt this system, the engineering firms in Calcutta will speedily place the articles on their lists. Detail drawings of the cappings are given in Plate 5.

The composition of the metal used in filling the cappings on the table is given in Mr. Gerrard's report as that which Mr. Ward, of the Bradford Colliery, has found to be the best. It consists of:—

Lead	...	...	60	%
Tin	...	...	30	„
Antimony	...	...	9	„
Bismuth	...	...	1	„

The antimony adds to the hardness, the bismuth lowers the temperature of fusion and gives a slight expansion in

[1] This has since been done and the test fully bore out anticipations. The rope broke without damaging the capping or the wires in the capping.

cooling. The writer cannot do better than quote Mr. Gerrard's further remarks :—

"There are several points to be closely observed :—(1) the steel socket or cap should be warmed to receive the metal composition ; (2) a dusting of resin dust within the cap around the wires acts as a flux to the composition ; (3) the wires of the rope should be well cleaned with paraffin after opening out ; (4) care should be taken that the wire wrapping around the rope at the limit of the wire opening should only extend just within the cap, not so far within as to prevent the metal from following well home to the end of the cap—it is very important that the inside of the cap should be well filled with metal ; (5) the capping should stand until quite cold, say two hours without being disturbed, to set well. It should further be observed the composition should not be remelted and used over again, as the antimony is liable to be reduced in remelting. If there be the desire to use it over again, the antimony should be renewed to maintain its proportion. Objection has been raised to this method of capping in that the heat of the composition may affect the temper of the wires of the rope. I have discussed this with distinguished metallurgists, and am satisfied there is no ground for this objection if reasonable care be taken. The temperature of the molten metal does not exceed 500 degs. Fahr. ; it may be much less. Any one desiring to try this method should experiment before actual use in the shaft, and should personally see the capping proved by test. At Ladyshore Colliery, for over 20 years cappings of white metal have stood the test of practical use in three shafts."

Sidings at the Top of Self-acting Inclines.

BY

Thos. H. Ward.

As usually arranged, the sets leave and come up on the same side alternately on a self-acting incline. With two sidings only at the incline head, the fact that the rope by which a full set is lowered must bring back a set of empties, necessitates this alternation of the sets. This difficulty greatly limits the number of sets, which can be dealt with in a given time for two reasons :—

1. The empty set, after it has been landed, has to be got out of the way, and the full tubs brought, and put into the position occupied by them, before the incline can be again operated.
2. The sidings must be laid on the level, so that power —generally the ubiquitous cooly in this country— has to be provided to operate them.

The result is that four or five trips an hour, with sets of two or four only, are all that can be got down one incline.

In 1897 the writer devised a plan for obviating this inconvenience (Fig. 8, Plate 7) and since that time seven or eight self-acting inclines have been put down, and no one would dream of reverting to the type it displaced.

Figs. 1, 6, 7 and 8 all shew variations of the same plan, which is to have three lines at the top, the middle line—which is of course available with equal ease to both ropes, and into which the sets of empties are automatically diverted from

either side by fixed points—being used to receive the empty sets, and the outside lines the full sets—one being taken alternately from either side. This plan allows all three lines to be suitably graded. The two outside lines at 1 in 25 or 1 in 30 will enable the sets to be self-starting, saving all labour. The full tubs run up against stop-blocks. The middle line is laid level or slightly inclining towards the drum. As the traffic is in the same direction always a "kick-up" can be fixed, preventing the possibility of any tub running back.

On referring to Fig. 1 (Plate 6) it will be seen that a length of 37 feet is required to lay in the points and crossings below the "brow" at the top of the incline, and that this is accomplished by ordinary C.I. points and crossings. These are shewn in Figs. 3 to 5 (Plate 6). Where there is plenty of room this plan is perhaps the most convenient. Where room is limited, either of the plans shewn in Figs. 6, 7 and 8 can be adopted. In these the distance occupied by the point and crossings below the "brow" is 24, 12, and 25 feet respectively. All these plans accomplish the same object.

Some interest attaches to the plan shewn in Fig. 8, (Plate 7) as this was the first of these inclines. It will be seen that the total length of the incline is so short that the two roads forming the "passbys" have to be continued, up to the point where they bifurcate, to form the third road at the top.

All these inclines are fitted with the well-known "long point," at the lower end of the "passby"—ensuring, automatically, that the ascending set will pass up the side down which the last full set descended. At the bottom the road bifurcates, the full tubs, always taking the same road, being diverted by a fixed point Fig. 5 (Plate 6). (Fig. 5

actually shews a fixed point diverting to the right. The reverse hand, diverting the traffic to the left, is of course used at the bottom of the inclines.)

Figs. 1, 6, 7 and 8 all shew different methods of arranging the sidings leading to the incline head, *i.e.*, of bringing the "full" and "empty" roads from each side into the three sidings at the incline top. It will be easy to follow these out, by inspecting the figures. The more elaborate plans are necessary when the traffic comes to the incline head from opposite directions. In this case, to get the maximum output the incline is capable of delivering, it will be necessary to arrange that the "fulls" from both directions can be placed in position to descend from either of the "full" roads, and similarly that the "empties" can be taken away in both directions.

If possible it is best to place the drum in front of the roads leading to the levels, the drum being placed overhead, as in that case the ropes do not interfere in any way with the moving of the tubs, and shunting operations can be continued while the incline is being operated. The drum can of course be placed behind, as shewn in the figures in dotted lines, and this is necessary in some cases.

A thick seam of coal (as will be realized by examining Fig. 2, Plate 6) greatly facilitates the fitting up of an incline of this type, to run sets of ten or more. The incline, illustrated in Fig. 1, is 800 feet in length, and lowers the set, carrying 5 tons of coal, about 75 feet vertically. Sets of ten tubs are run, and about one minute is the actual running time. At the top the full tubs can of course be put in position, and the "empties" taken away, while the sets are running. This is not possible at the bottom as the men and horse would be in danger. Taking four minutes as the time taken by a horse to bring in the empty set and leave with

the last full set, one trip can be made every five minutes, or twelve trips an hour, or an output of 60 tons an hour. More has actually been done.

Discussion on Mr. Fermor's Paper on "Manganese in India."

Mr. W. H. Pickering desired to express the general feeling that this paper was of great practical as well as scientific value, and to congratulate the author on the award to him of the Government grant. There had been a demand for the paper from all parts of the world. Since it was read the output of manganese-ore in India has more than doubled, and this brings nearest the time when the more easily quarried ore will be exhausted. He could hardly agree with the author, however, in his gloomy view that the extra cost of mining would render competition with open working impossible. When the time came effective and economical mining methods would be devised as had previously been done in the case of other minerals. Judging from the photograph of the tentative attempt to mine manganese, wide galleries were opened in the face of the quarry. Such a method could not be successful. It would be necessary to drive narrow galleries to the far end, and work out the mineral backwards. It would probably be necessary to fill in the excavations with material from the surface, but this could be economically done, for the overburden could be used and the ore quarried and mined at the same time. Could Mr. Fermor say whether manganese was mined in other countries? Water might be a difficulty, but with modern pumps, enormous quantities of water could be raised at a small cost. In the Vizanagram district where the rainfall is only 45 inches, water is raised from thousands of wells for irrigation. Mr. Fermor had made several practical suggestions to prevent waste in mining, but had not told them whether the manganese dust, which is made in working, could be used. At present it

is thrown away. Silver was sometimes found in manganese-ore in such high percentages that it pays to extract it: possibly the author could state whether this is the case in India, and if systematic examinations for this or other precious metals had been made. At the Barakar meeting Mr. McFarlane said that he proposed to manufacture ferro-manganese. Had anything been done in that direction?

Major F. C. Hughes asked if that dust could not be used for production of chlorine for bleaching purposes.

Before replying to Mr. Pickering Mr. Fermor first wished to express to the Institute his gratitude to them for the honour they had done him by the award of the Government Prize for 1906. He hoped to be able in the future to justify this award to a certain extent by his continuous regard for everything connected with the welfare both of the Institute and of the mineral industries of the country. In replying to Mr. Pickering's questions he said that he had not meant to convey to the readers of his paper any particularly unfavourable impressions as to the future of the manganese-mining industry in India, as he believed that, given the right combination of circumstances, it would flourish for many years to come. With regard to the possibility of extracting manganese-ore in India by underground mining as distinguished from opencast work or quarrying, he wished to point out that the price of manganese is very variable, and as long as there are many deposits which can be worked by opencast methods the prices are not very likely to rise much, if at all, above their present level, say sixteen to eighteen pence a unit, whilst they are likely to drop at times to something like the level at which they stood in 1904. In the latter case many of the deposits which are now being worked at a handsome profit would have to be closed down, and the Indian

output would probably drop much below the enormous figures for 1907 (probably about 400,000 tons). It may be that it might pay to mine a few of the more favourably situated deposits when prices are at their present values, but such methods are, of course, at present unnecessary as long as large quantities of ore are easily obtained by opencast working. If the supplies of ore thus easily workable in India should give out before it has been found necessary to mine manganese-ores at the majority of the foreign-producing areas, whilst the price of manganese fluctuates between the values of say ten pence to eighteen pence a unit, then it would probably be found that the Indian manganese-industry would reach a rather low level until one of two things should happen. When the effect of the prospective considerable lessening of the supplies of Indian manganese-ore had become felt on the market, if no compensating supplies could be obtained from other parts of the world, then the prices would speedily rise above their present level so that it would pay to extract the remainder of the Indian manganese-ores by true underground mining. The other factor that could render this method of extraction generally possible would be the creation of a demand for this mineral in India itself by the birth of steel-making on a large scale in this country. With regard to Mr. Pickering's question as to whether manganese is mined anywhere out of India, he pointed out that this is the case in several countries where the deposits are situated near the iron-smelting centres. Thus it has been found economically possible to mine the large deposit at Miguel Burnier in Brazil as this deposit is, comparatively speaking, not so very far removed from the American markets; whilst in places situated much nearer the smelting centres it has been found possible to mine even veins of manganese-ore of comparatively small width, as for example North Wales, and at several places in Germany;

whilst at Crimora in Virginia, pockets of ore irregularly scattered through clay have been extracted by underground mining. With regard to the water question it is obvious that given sufficiently powerful pumps this difficulty is greatly reduced. The point is that at first only very small pumps, or some primitive means of removing the water, such as baling, were in use. Now, however, pumps of moderate power are being, or have been, set up at many of the mines, both in the C.P. and Vizanagram area. The water so extracted might sometimes be usefully employed for irrigation purposes perhaps with profit to the mine owners. In one instance, he believed, this is actually done, the water from the Garbham pit being distributed to the paddy-fields near by. Mr. Pickering asks about the possibility of making use of the manganese-ore dust produced in the course of mining.

In some of the deposits there is undoubtedly a very considerable quantity of such dust formed. The amount so formed depends naturally on the physical character of the ore at the particular quarry. When he first visited the Kándri deposit in the C.P. in the beginning of 1904 he was struck by the fact that practically all the ore exposed in the workings on South Hill was hard and finely crystalline, so that the proportion of dust produced in working was very small indeed. In fact it seemed at first sight as if the deposit, on being quarried, would yield almost 100 % of merchantable ore. At his second visit, however, this last December, he was surprised to find that, now that the outcrop had been quarried into to some considerable extent, the whole mass of the ore was no longer hard and non-friable. On the contrary a very considerable proportion of it was either moderately or very friable, with the consequence that there is now a very large amount of dust formed in the course of working this deposit. When he enquired if any attempt was made to utilize this

dust, he was told that there was no market for such material, and that in consequence the dust was thrown on to the waste-heaps with the other useless material. Such ore could, however, be made merchantable if it were converted into briquettes. He believed that this same difficulty has arisen in the Brazilian mines where nearly all the ores are much more friable than the Indian ores, and that it has, to a certain extent, been successfully overcome by briquetting. It is of course not very probable that briquetting would be a commercial success in India at present, owing to the fact that the demands can be easily supplied from the hard ores, and because it would be very difficult to collect the dust which is not often formed in any quantity.

The occurrence of silver in manganese-ore, to which Mr. Pickering refers, is, of course, a rare phenomenon, the classical example being the manganiferous veins of the Rocky Mountains, specially in Colorado. Here veins of manganiferous iron-ore carry varying percentages of silver. Such ores can be used in three different ways according to the percentage of silver they contain. When this is sufficiently high the ores are smelted as silver-ores. When this is not sufficiently high for the ore to be worth smelting alone for its silver, the ore can be made use of in two ways. If, as is usually the case, the manganese percentage is too small for the ore to be worth smelting for its manganese, it is used as a flux in smelting silver-ores, the small amount of silver being thus recovered whilst the manganese acts in the same way as iron in fluxing off the gangue of the silver-ores. If, however, as sometimes happens, as for example at Leadville in Colorado, the manganiferous ore, low in silver, is yet sufficiently rich in manganese and iron, it is used for the manufacture of spiegeleisen.[1]

[1] Penrose, An. Rep. Geol. Sur. Arkansas, 1890, Vol. I, p. 90.

In India, however, as far as he was aware, no systematic examinations of the manganese-ores for precious metals has been carried out, although in several cases small amounts of various metals used in the arts have been returned in analyses as being present in the ore analysed. Copper, lead, zinc, cobalt and nickel have been thus found, although only in very small quantities. With regard to the manufacture of ferro-manganese at Barakar he had heard nothing further and suggested that the question should be referred to Mr. Macfarlane.

Mr. E. H. Roberton then remarked that he had once been able to visit the manganese mines in North Wales and that the ores being worked there occur as thick veins traversing rocks of Cambrian age. The ores consisted of oxides in which the peroxide occurred in thin streaks which, as is well known, is a very soft and powdery ore. He asked if this was the composition of the ore which broke down into powder at Kándri.

Mr. Fermor, in reply to this question, said that the composition of the hard ore which was first found at the outcrop at Kándri was a mixture of the two minerals braunite and psilomelane, in which the braunite was present as tiny granules set in the psilomelane, the latter mineral acting as a cement to the braunite. The softer ores found at a greater depth, however, contain a much smaller proportion of the cementing psilomelane. The consequence is that the braunite granules are less firmly held together and the ore is much more friable. In some parts of the ore-bed this cement is practically absent, so that the ore consists almost entirely of an aggregate of fine grains of braunite. This, of course, is the ore which so often breaks down completely into powder when quarried, and it may be stated as a

general rule that the more friable the Kándri ore is the larger proportion of braunite does it contain. Hence the composition of the dust thus formed must approximate to that of braunite, which is a mixture the sesquioxide and metasilicate of manganese, and therefore not to a peroxide.

Major F. C. Hughes then asked if this powder would not be of value in the manufacture in this country of chlorine.

Mr. Fermor, replying, said that the value of a manganese-ore depends on the amount of available oxygen it contains, *i.e.*, on the amount of manganese-peroxide present. Now braunite, as can be seen at once from its chemical formula, $3Mn_2O_3,MnSiO_3$, contains a very small proportion of peroxide compared with pyrolusite, which, when pure, consists entirely of this oxide of manganese. Consequently it could never be economically used as a source of chlorine. At some of the Indian deposits, however, there are certain quantities of pyrolusite suitable for this purpose, but this does not solve the problem as to what can be done with the dust formed at most of the C.P. deposits, where from the character of the ores the dust formed must be largely braunite. At present it seemed to him that there is no alternative to the present practice of throwing it away, unless an attempt be made either to bag the powder and send it to Europe or America in that condition or to briquette the powder in India.

Mr. R. R. Simpson wrote that the writer of the paper was apparently inclined to look upon the whole of the manganese deposits of India of eruptive origin. For the Vizagapatam deposits the evidence in favour of this view seems to be fairly conclusive, but in the case of the C.P. beds there appeared to be considerable grounds for the opinion

that the ore-bodies were of sedimentary origin, and derived from the decay of an ancient land surface in much the same manner as the Chilian manganese deposits, or as certain of our Indian laterites are considered to have been formed.

On the subject of methods of working Mr. Fermor, whilst bestowing well-deserved praise upon the owners of certain properties and their officials, had passed severe strictures upon others. It should be remembered, however, that many of these adventures were commenced upon a small scale with the slenderest financial resources, and that it was often of vital importance to the continuance of working that an immediate profit should be made, by which capital for more extended operations could be obtained. Managers were consequently obliged to go for the ore actually in sight, and to cut down "dead work" to the lowest possible minimum. The fact, however, that certain of the mines are worked scientifically and at a profit was gratifying and contrasted favourably with the economics of the Indian mica industry, in which probably, not a single scientifically worked mine has ever been successful.

In view of the early exhaustion of the richer ores foreshadowed by Mr. Fermor, it would be of interest to know whether there is an opening for the introduction of ore-dressing machinery to enable the leaner ores to be concentrated to a richness fit for shipment. Apparently nothing but hand-cobbing is practised at the present time.

Mr. Fermor, in reply, wrote that Mr. Simpson raised a very interesting point when he questioned the opinion put forward in this paper that the manganese-bearing rocks of the C.P. are of eruptive origin. At the time it was written he had only had the time to examine microscopically a very

small proportion of the rocks collected. Moreover, practically no analytical work had then been done on the Indian manganese minerals and rocks. Consequently he was compelled to rely almost entirely on field evidence. The field evidence favouring the igneous origin of the manganese-silicate-rocks of Vizagapatam seemed very conclusive. With regard, however, to the manganese, silicate-rocks of the C.P. the evidence was much less certain. And as the C.P. rocks seem to be somewhat similar to those of Vizagapatam especially in the presence of an orange to red garnet rich in manganese, which was seen in both areas to have given rise to at least a considerable portion of the manganese ores, and as it seemed improbable that such an unusual mineral as a highly manganiferous garnet should be of igneous origin in one area and of metamorphic origin in the other area, the rocks of the C.P. were brought into line with those of the Vizagapatam district. This was done in face of the fact that in the field, before he visited the Vizagapatam district, he had come to the conclusion that the C.P. manganese-silicate-rocks were the product of the metamorphism of sediments. During the ten months elapsed since this paper was read, he had been able to carefully examine a very large number of slides under the microscope and to carefully consider all the evidence then available together with some obtained since, and had been driven back to the theory originally formed in the field, namely, that the C.P. manganese-silicate-rocks have been produced by the metamorphism of manganiferous sediments; and have further decided that these sediments were deposited in Dhárwár times. The sediments so metamorphosed must have been originally deposited as oxides (or less probably carbonates), probably in basin-like areas in which waters were able to accumulate and slowly deposit their dissolved manganese

salts in the form of the above-mentioned oxides. Sometimes the oxides were deposited comparatively free from admixture with silts such as sand and clay, whilst at other times such silts may have been either intermixed or interstratified with the manganese-oxides. Towards the finish of the Dhárwár period of sedimentation the whole series of sediments was involved in the great series of tectonic disturbances which brought about the metamorphism and folding of the Dhárwár rocks. In some cases this action was sufficiently severe to produce a complete mineralogical re-arrangement of the constituents of the rocks, so that they have been thoroughly re-crystallized, as in the Nágpur-Bálághát area of the C.P., where the existence of the Dhárwár series has not been previously recognised, except in the less metamorphosed form known as the Chilpi Ghat series. When the original sediments were fairly pure manganese-oxides, the product has been a crystalline manganese-ore formed by the compression and crystallization of these oxides. But when the manganese-oxides were either interlaminated with or intermixed with layers of silt, an interaction has taken place between the manganese-oxides and the sands and clays with the production of rocks composed of the manganese garnet, spessartite, and of rhodonite and quartz. In some cases these manganese-silicate-rocks have remained comparatively fresh up to the present day, but frequently they have suffered chemical alteration with the formation of manganese-ores. Thus the manganese-ores of the Nágpur-Bálághát area of the C.P. have been produced in two ways. Some have been produced by the direct compression of the original fairly pure manganese-oxide sediments, and some have been formed, by subsequent chemical change, from the manganese-silicates produced by the metamorphism of the original mixtures or interstratifica-

tions of manganese-oxides with sand and clay. This work had not lead him to alter his views with respect to the origin of the Vizagapatam manganese-silicate-rocks, so that it was necessary to admit the presence in India of two great series of manganese-silicate-rocks, one of which, that of the C.P., is the product of the metamorphism of sediments, whilst the other, that of Vizagapatam, is of the nature of an igneous intrusive. In both cases the chief manganese-silicate is a manganese-garnet, but whilst that of the C.P, conforms fairly well in composition to spessartite, that of Vizagapatam is about halfway between spessartite and andradite and is characterized by the presence of a rather high percentage of lime. The chief mineralogical differences, however, lie in the comparative rarity of felspar and apatite in the C.P. rocks and their abundance in Vizagapatam. Moreover, whilst the manganese-ores in the C. P. have been produced in two ways as outlined above, those of Vizagapatam have been produced in only one, namely, during the chemical alteration of the manganese-silicate-rock. He had already given Mr Holland notes to the effect of the above paragraph, which will appear in the "Records of the Geological Survey of India," in the Annual Report of the survey for 1906. He welcomed, however, the opportunity of putting these altered views before the Institute, and thanked Mr. Simpson for providing the opportunity.

With regard to Mr. Simpson's remarks about methods of work, he fully agreed with most of what he said, except that some of the crude work he had seen could not be excused on the ground of the deposit being worked only just paying its way. In working a deposit in the alluvium it is obvious that it would cost very little to test the extension of the deposits by putting small cross-cuts a little distance from the quarry. Instead of this it has often been the case that

when a mine operator has desired to test the extension of his deposit that he has put down a few random pits which, as likely as not, miss the ore-band. Frequently, as a result of not ascertaining the direction of strike of a deposit as soon as possible, the waste has been dumped on to the immediate extension of the ore-body, so that when it is later found that the ore-body runs under the huge heaps of waste, it becomes a question as to whether it will pay to shift this waste, or whether it will not be cheaper to abandon the particular portion of the ore-body thus covered up. A recent visit to a few of the C.P. mines in December 1906, showed that there had been a considerable improvement in the working since his first visit in 1903-04, and as the result of a considerable increase in the number of qualified mining men employed on the C.P. deposits he expected there would be a further improvement in the methods of work during the next year or two.

With regard to Mr. Simpson's question about the possibility of concentrating the leaner ores by mechanical means instead of cleaning them by hand-cobbing, he thought that with the hard ores of the C.P. there is at present practically no scope for the employment of such methods. At present all ore is rejected which is under about $1\frac{1}{2}$ inches in diameter. As mechanical cleaning would involve the reduction of the ore to a much smaller size than this, it is obvious that before any such mechanical concentration or cleaning can be thought of, it is necessary to solve the problem of the employment of the smalls and dust. There is a very large amount of ore thrown away because it is intimately mixed with quartz and unaltered silicates, such as spessartite and rhodonite. This admixture is frequently so intimate that the one contained in the rock thus thrown away could not be separated from the gangue and

raised to a 50 % basis without breaking up the ore almost to the condition of powder. By doing this, however, it would be possible to save many thousands of tons of ore at present being thrown away, but most of the ore so recovered would be in the form of dust which would need briquetting.

Discussion of Mr. Ward's paper on the Examination of Wire Ropes.

Mr. Grundy referred to the corrosion of wire-ropes owing to the access of water in parts where spun yarn was used as an outer protecting wrapping. He concluded that the lesson to be learnt was not to allow such wrappings to be left in one position, that they should be frequently changed and the rope well greased.

Mr. W. P. Griffiths suggested that the opinion of the makers of wire-ropes should be obtained as to whether any deterioration in the tensile strength of the rope would be caused by the method of untwisting the strands advocated by Mr. Ward.

Prof. Brühl formulated four objections to the untwisting method of Mr. Ward :—

(1) The difficulty of getting the untwisted strands of the rope to return to their original position, and the consequent unequal distribution of strain on the imperfectly readjusted strands.

(2) The access of water along capillary spaces thus formed and which did not exist before, causing chemical action and consequent deterioration.

(3) Some forms of lubricants were also stated to help in the rusting of ropes.

(4) He referred to the well-known fact that the tensile strength of steel wire depended upon the "skin" being kept intact; anything therefore, which tended to impair that skin (such as might

easily happen in the untwisting process) should be avoided as much as possible. He thought this the most serious objection of the four put forward by him.

Mr. F. J. Agabeg asked to be informed in how many places it would be necessary to open out a 1,000 ft. wire-rope, since it would be quite necessary to know that every individual 20 ft. of it was in good condition.

He was also of the same opinion as Prof. Brühl that untwisting and retwisting the rope would cause an unequal distribution of strain.

Mr. Ambler remarked on the effect probably produced by the acids existing in commercial tar.

Mr. Ward, in reply, said he thought no rope-maker would object to his method of opening out a rope. With reference to Prof. Brühl's objections, he maintained that as regards increased capillary action inside the rope, every wire composing it was always in a condition of touching or not touching its neighbour wires; and therefore the opening out of the rope would make no difference.

As regards unequal distribution of strain he said this was quickly readjusted in practice, and that when the rope had made a trip or two up and down no one could tell where the opening had been made.

As to the question of damage to the skin of the wires, he pointed out that mining engineers have to adopt a wide margin of safety because all ropes must get damaged on the surface during winding and the ordinary wear and tear of every-day use.

In answer to Mr. Agabeg he said the method would be to divide the rope, say, into four portions and examine these.

Afterwards if signs of deterioration were noticed it would be necessary to further subdivide these portions for fresh examinations, and so on.

He also replied to Mr. Ambler.

Mr. Thos. Cradock (of Messrs. George Cradock and Co., Wakefield) wrote that the usual method adopted for examining a rope for internal corrosion is to cut off a piece from the ends and pull the rope to pieces and look what it is like. This is the only reliable way. In nearly all cases corrosion is found at the cage end of the rope first, as this is often the portion that gets the least grease, and also the water naturally runs to this end of the rope. This is one of the reasons why a rope should be recapped frequently.

If it is desired to examine the condition of a rope internally at some portion of the rope away from the end, and not destroy the rope, the only method is to put on two hemp rope twitches and use two long iron bars and untwist the rope slightly for a little distance and then put in a round marlinspike so as to see what it is like. This requires very carefully doing or a rope will be damaged.

Where ropes are subject to corrosive influences it is advisable to have them galvanised. In all cases ropes should be thoroughly well and continually greased.

Also with regard to opening up ropes, he thought the following extract from an affidavit made by Mr. George Cradock on this subject might be of interest: —

"I observe in the evidence that the opinion was ex-
"pressed that the wire-rope ought to have been opened up
"every week or for night, at intervals of about twenty feet,
"by opening with a marlinspike to see if the oil is saturat-
"ing the centre core. In my experience I have never heard

"of this being done, and consider it a most dangerous and "prejudical proceeding or practice. It would displace the "position of the strands in the rope and it would be detri- "mental and cause damage internally to the rope by the "use of marlinspikes to open the strands apart. I have "large numbers of winding ropes at work, in many coun- "tries, but this method is never adopted."

With regard to ropes and chains breaking, he would suggest that it be obligatory to recap every winding rope at intervals not exceeding four months. The rope which goes over the pulley-wheel and comes down into the shaft, in picking up the load every time, is compressed on the top of the wheel by a sudden blow, and it is therefore important that the position of the blow should be moved by recapping and cutting shorter. He thought it should be a special rule that the rope is to be recapped every four months so as to take off the point of pick-up on the pulley-wheel. There was another reason : in bad weather, when the rope is on the top of the pulley-wheel, the strands of the rope are open, and the rain, etc., getting into the strands, encourages internal corrosion. By taking three or four feet off the cap the tread is altered and taken to another place, and therefore it is important that the rope should be recapped at intervals.

NOTES, ABSTRACTS, AND REVIEWS.

Notes on Metals and their Ferro-alloys used in the Manufacture of Alloy Steels.

By O. J. STEINHART.—A full abstract of this paper, read before the Institution of Mining and Metallurgy, is given in the *Mining Journal*, LXXIX, pp. 93, 94, 128, 129, 150, 179, and 180 (1906).

The following is a list, in order of consumption and importance, of the metals used by steel-makers either alone or as ferro-alloys:—Manganese, nickel, chromium, tungsten, molybdenum, vanadium; and experimentally, cobalt, titanium, uranium, and recently, tantalum. The author confines himself to the origin, statistics, manufacture and composition of these metals and their alloys, and, with the exception of manganese, deals with them all in turn. The chief value of the paper lies in the fact that it brings together the great variety of metallurgical processes which have been devised for dealing with this interesting group of metals, and its perusal brings forcibly before one's notice the gigantic strides which metallurgical practice has taken in recent years. In addition to the dry furnace—and wet chemico-metallurgical—processes, which but a comparatively few years ago accounted for the extraction of nearly all the commercial supplies of metals from their ores, we now have not only (1) the electro-metallurgical processes as applied to the direct smelting in the electric furnace of such metals as chromium, tungsten, molybdenum and vanadium, and to the electrolytic refinement of copper and other metals, and (2) the extension of the principles of bessemerizing to the metallurgy of copper and nickel; but also such beautiful processes as the Mond process for extracting nickel, and the Goldschmidt aluminium process available for extracting almost any metal from its oxide. The author mentions the application of this last-named process to the production of chromium, molybdenum and ferro-vanadium.

L. L. F.

Corundum and its Occurrence and Distribution in the United States.

By J. H. Pratt, *Bulletin*, No. 269, *U.S. Geological Survey*, 175 pages, 18 plates (1906).

This interesting monograph treats the subject of corundum in the following sections :—

Historical sketch.
Nomenclature of corundum.
Physical properties of corundum.
Chemical composition of corundum.
Description of the three varieties (sapphire, corundum, and emery).
Corundum-bearing rocks in the United States.
Foreign occurrences of corundum.
Minerals associated with, and alteration products of, corundum.
Origin of corundum.
Distribution of corundum in the United States.
Distribution of corundum in foreign countries.
Technology of corundum.
Suggestions to prospectors for corundum.

Lack of space forbids any account of most of these sections, but the following paragraph (p. 27) is worth quoting as it gives a summarized view of the mode of occurrence of this mineral :—

"Corundum has been found in igneous and metamorphic rocks in alluvial deposits. Where it occurs in the igneous rocks it is either as a direct constituent of the more acid instrusive rocks, or it occurs as segregated masses near the periphery of the basic intrusive rock, or is associated with inclusions that have been picked up by the instrusive rocks. In the metamorphosed rocks the corundum is either one of the original constituents of the igneous rock that has been subjected to metamorphism, or the result of regional metamorphism by which shales, bauxite, or other rich aluminous minerals have been converted into corundum, or it may be due to contact metamorphism, the corundum occurring simply in the narrow zone adjoining the intrusive rock. In the alluvial deposits the corundum is found either in the recent alluvium composed of soil, or in sands, or in gravels."

In the sub-section—1⅓ pages long—treating of the corundum occurrences of India, there are several errors in place-names and geography to which attention must be drawn, as otherwise they will be repeated elsewhere in the manner characteristic of such mistakes. Thus, on page 153, the author speaks of the "Pararapatti area in the Salem district of the province of Upper Burma." The first name should be Paparapatti, while Salem is in Madras and not in Burma. Moreover, the felspathic matrix in which the corundum of this area occurs is not, as stated by the author, "composed essentially of anasthite and hornblende" (although this is the case in the Sithampundi area of this district), but is, according to Mr. Holland,[1] whose work the author is abstracting, composed principally of deep flesh-coloured orthoclase with microperthitic or cryptoperthitic intergrowths, possibly of plagioclase. The author next speaks of Pipra in South Rewah as being about 250 miles north of Calcutta although it is really about 400 miles W.N.W. of this city. The information he requires relative to this occurrence is contained in papers by F. R. Mallet in the *Records Geol. Surv. Ind.*, V, pages 20-22, and VI, page 43, and in Holland's manual on corundum (p. 50). "Barampur" and "Manbhoorn" are doubtless printer's errors for Balarampur and Manbhoom (more correctly spelt Mánbhoom).

In the section on Burma, Siam and Ceylon, sapphires are said to have been obtained from "Simla Pass in the Himalaya Mountains." It should be remarked that Simla is in India and that there is no pass of this name.

The report is profusely illustrated with diagrams, maps and photographic reproductions, and can be recommended to the notice of every one interested in corundum.

L. L. F.

The Refractory Uses of Bauxite.

By A. J. Aubrey, *Eng. and Min. Jour.* LXXXI, 3-2-6, pp. 217, 218.

The author describes the process of making bauxite bricks and discusses the relative merits of bricks made of bauxite and magnesite

[1] Manual of the Geology of India, Economic Geology, Part I, Corundum, p. 41, (1898).

respectively for lining basic open-hearth steel-melting furnaces. His experiments indicate that bauxite is at least as good as, if not better than, magnesite for this purpose. The brick must be high in alumina and as low as possible in silica and oxide of iron. The bonding material used is lime free from silica. He mentions a brick containing as low as 6 or 8 % of silica as being, apparently, the best that can be obtained. It is obvious that from the Indian bauxites, which frequently only contain 1 to 2 % silica, an article superior even to this could be produced. Cases are also mentioned where bauxite bricks were found to be much superior to those made of fire-clay both for lining the hot zone of a rotary Portland cement kiln and also for constructing the hearth of a lead-refining furnace in which the silicate scums formed on the surface of the molten lead corrode very badly the fire-clay bricks usually used. In the latter case the bauxite lining was found to last five or six times as long as the fire-clay one.

L. L. F.

The Tin-Deposits of the World.

By Sydney Fawns, pp. xii and 240 (*The Mining Journal*), 1905.

This work is the result of an attempt to produce a collected account of the tin deposits of the world and of the method of mining them. The first chapter deals with the common forms of stanniferous minerals and the early history of tin-mining, while the second discusses the form and mode of occurrence of tin-ore deposits. The remaining chapters consist of descriptive accounts of the tin-deposits of different parts of the world with the intercalation and addition of chapters on alluvial tin-mining, tin-crushing and dressing machinery, dredging for tin, methods of tin-analysis, statistics of tin-production, and a bibliography of the more important papers on the subject. Separate chapters are devoted to the Mount Bioschoff and Dolcoath tin mines respectively.

The book is professedly written for the tin-miner and investor, and will be found by them to be a very handy little compilation. Its scientific value, however, is much reduced by the frequent misprints and inaccuracies, and it is to be hoped that in a second edition Mr. Fawns will take the opportunity of correcting these. By the addition

of a discussion on the origin of tin-deposits *in situ* (which is expressly excluded from the present scope of the work, see p. 8) the book would also be made attractive to geologists, and even miners must desire to know something of the origin of the tin-deposits they are working.

An account of the tin-deposits of British Burma is taken from a paper by Mr. T. W. H. Hughes. It appears, also, from the reports of Messrs. Gilfillan and Cox on the alluvial tin-deposits of the Tavoy district, that the concentrates obtained by washing the gravel of the Golden Stream near Myitta, contain both gold and silver in addition to the tin-stone. The author seems, however, to be unaware of the existence of deposits of tin-stone in other parts of the Indian Empire, such as Karenni and Házáribágh.

L. L. F.

I.—On the Origin and Relations of the Nickel and Copper Deposits of Sudbury, Ontario, Canada.

By ALFRED ERNEST BARLOW. *Economic Geology*, I, pp. 454-466 (1906).

II.—Notes on the Origin of the Sudbury Ores.

By DAVID H. BROWNE. *Ibid.*, pp. 467-475.

I.

The former paper starts with a historical résumé of the literature of this subject, tracing the development of, and oscillation between, the two views now held with regard to the origin of the Sudbury nickel-copper deposits. One view, expounded as recently as 1903 by C. W. Dickson, is that the Sudbury ore-bodies have been formed by metasomatic replacement effected by aqueous solutions percolating along crushed and faulted zones, which occur either well within the basic eruptive (norite) or at its contact with the other rocks of the district, namely, granitic gneiss, quartzite, or the metamorphorsed representatives of a series of basic sedimentaries known as "greenstones." The second view, held by J. F. Kemp, T. C. Walker, Vogt and others, is that these ore-bodies are the result of the differentiation of a norite magma leading to a concentration of the basic sulphides, pyrrhotite, chalcopyrite and pentlandite, once uniformly distributed through the magma.

The author, who claims to have first put forward (in 1891) the theory of an igneous origin for these masses of sulphide material, describes in the second part of his paper the nickel-bearing eruptive. This can be divided into two portions which pass one into the other :—

1. "A basic portion : including certain gabbroid rocks, chiefly, at least of the norite facies, with their derivative diorites, with which the nickel and copper-bearing sulphides are immediately associated.
2. An acidic portion : comprising large areas of rock of granitic type, with well-marked gneissoid structure, the prevalence and abundance of the graphic intergrowth of the quartz and feldspar, known as granophyre or micro-pegmatite, having suggested the name 'micro-pegmatite' by which this rock is now generally known."

This intrusive sheet, which lies to the N.W. of Sudbury, crops out for a length of 38 miles in a N.E. direction, the width of exposure (including both the norite and micro-pegmatite) varying from 1 to 4 miles.

The norite often shows ophitic structure, and in addition to hypersthene or enstatite, primary hornblende bordering the hypersthene, biotite and labradorite, contains an abundance of original quartz which sometimes forms a micrographic intergrowth with the plagioclase. Monoclinic pyroxene and olivine are also sometimes present. Apatite, magnetite (usually highly titaniferous), zircon, pyrite, pyrrhotite and chalcopyrite are almost always present. "These sulphides are distinctly of primary origin, and were among the earliest of the minerals to crystallize from the original magma, antedating even the magnetite, in some cases, for grains of pyrrhotite were noticed completely enclosed by the iron-ore." The sulphides often occur in parts of the norite which are but slightly altered, and are often so abundantly disseminated as to justify the name of "pyrrhotite-norite" sometimes used.

This rock is described in detail to show that the sulphides have crystallized from fusion; and, if this be admitted, it is only a step further to suppose that the sulphides have concentrated themselves to form ore-bodies by the same, still imperfectly understood, process of

magmatic segregation by which many deposits of titaniferous magnetite are thought to have been formed.

The author also describes in detail the gabbro-diorites and micropegmatites forming part of the same mass of igneous rock.

II.

After recapitulating the two theories as to the origin of the Sudbury deposits, with a brief account of the evidence in favour of each, the author proceeds to attack the problem from what he describes as "an economical and metallurgical standpoint," and the result of his investigation is to add further support to the magmatic segregation theory.

He first shows that the ores once formed were not removed, changed, or in any way disturbed by surface action, except for a few outlying deposits which may have been affected by earth movements after the segregation of the sulphides. His arguments in support of this are:—

1. The ores are remarkably monotonous, consisting of pyrrhotite, chalcopyrite and pentlandite, with practically no pyrite, marcasite or other sulphides.
2. Practically speaking, any replacement minerals such as chalcosite, cuprite, malachite or chrysocolla, or hydrated nickel minerals, are quite absent.
3. The ore-deposits are water-tight, *i.e.*, contain no vugs, drusy cavities or crystals.
4. The mines are, as a rule, dry.
5. Water has little or no effect upon the raw ore, the mine water being pure enough for drinking purposes.
6. There is very little gozzan. Many deposits have retained the bright polish produced on their outcrops in glacial times.

He then gives figures showing that the copper and nickel sulphides are distributed in the same manner in the ore-bodies as the copper-nickel sulphides segregate in a pot of molten matter, in which the copper tends to move outwards towards the cooling sides, while the nickel is concentrated towards the centre.

The author also finds that what he calls the "residual rock,"

occurring in the ore-bodies, is extremely aluminous and very sticky when molten, and regards it as the remainder or dregs of the magmatic segregation. He quotes analyses by T. L. Walker to show that there is a gradation from granitic rocks through diorite and norite to the "residual" rock entangled in the ore, this gradation corresponding with the fusing points of the rocks, the acid rocks being the most infusible and hence the first to solidify, and the most basic rocks the most fusible and consequently the last to solidify, the readily fusible sulphides accompanying the basic rocks.

The author, in the concluding paragraph, says that the aqueous theory "does violence to the whole present condition of the country, and finds no local support except among those who have studied extreme conditions in small veins on the outer edges of the nickel belt," where "even the most ardent disciple of the magmatic theory willingly concedes local and secondary alterations."

L. L. F.

1. **The Microscopic Examination of Opaque Minerals.**
   By W. Campbell. *Economic Geology*, I, pp. 751-766 (1906).

2. **A Microscopic Examination of the Cobalt Nickel Arsenides and Silver Deposits of Temiskaming.**
   By W. Campbell and C. W. Knight. *Ibid.*, pp. 767-776.

3. **Microscopic Examination of Nickeliferous Pyrrhotites.**
   By W. Campbell and C. W. Knight. *The Engineering and Mining Journal*, LXXXII, pp. 909-912.

The first paper gives an account of the methods to be employed in the preparation of polished surfaces of the opaque minerals, such as the common sulphides, for examination by the means used in metallography for dealing with polished and etched surfaces of metals and alloys. The author describes all the stages of the process, namely, the grinding, polishing, etching, mounting, examination, and finally the photographing of the preparation. A short account is also given of the microscope suitable for the examination of the opaque minerals.

The second and third papers give an account of the application of these methods to particular cases, and it is not too much to say that the authors have, by the application of this branch of practical metallo-

graphy for mineralogy, opened up a new branch of mineralogical research and have made a beginning in placing the opaque minerals on somewhat the same footing as regards exactitude of microscopic treatment, as the minerals which are transparent to transmitted light when ground to thin sections. These papers also show the value of the method in working out the paragenesis of the metalliferous minerals usually found in ore-deposits.

The second paper deals with the cobalt-nickel-silver veins of the Temiskaming area in Ontario. From the microscopic examination of the polished preparation the order of deposition of the minerals present is deduced to be the following:—Smaltite, niccolite, calcite, argentite, native silver, native bismuth; whilst erythrite and annabergite have been subsequently formed on the outcrops by the oxidation of the cobalt and nickel minerals. The relations of the various minerals one to another are illustrated by beautiful photo-micrographs which illustrate well the value of this method of examination of opaque minerals.

The third paper is of the same character as the previous one as regards method of treatment. The nickeliferous pyrrhotites of several well-known localities, both in America and Europe, are discussed and illustrated by photo-micrographs. The results obtained point to a similar origin for all these deposits, and the authors think that the mode of origin is as follows:—"That the basic rocks have been more or less shattered or broken; that solutions have replaced the rock matter wholly or in part by pyrrhotite; that later on the pyrrhotite, etc., was also broken, and the deposition of pentlandite and chalcopyrite followed, the pentlandite coming down before the chalcopyrite." It will be seen from the above that the work of these authors does not support the theory advocated in the preceding abstracts, that the nickeliferous pyrrhotites of Subdury and elesewhere are the result of magmatic segregation from an igneous magma.

L. L. F.

The "Kyle" Hand Diamond-Boring Rig.

Colliery Guardian, Vol. XCII, No. 2390, p. 745, dated October 19th, 1906.

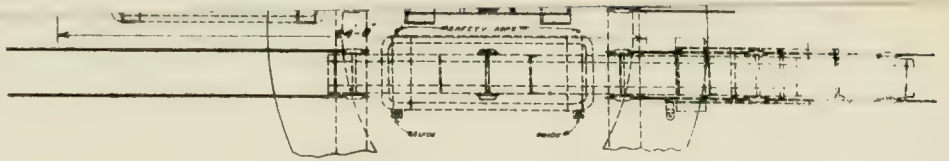
At a recent meeting of the Mining Institute of Scotland, Mr. Thomson, of Motherwell, described a hand diamond-boring machine

known as the "Kyle." The machine, which weighs 4½ cwts., can be actuated by four men—one leader, two at the handles, and one at the pump. Three gallons of water per minute are required. On the handles a speed of 100 revolutions a minute can be maintained. For a 2⅝ diameter hole, eight diamonds are required, from 2½ to 3 carats each, at, for ordinary coal measures ground, £1-10-0 per carat. An account of an actual boring was given, 725 feet being bored in 83 days by 557 shifts of a man. This machine might be worth the attention of members, especially in cases where it is required to bore from one seam to another, instead of from the surface, as it is claimed that the machine can be easily dismounted for placing underground, and it only requires 12 feet of head room.

G. F. A.

5th OPERATION

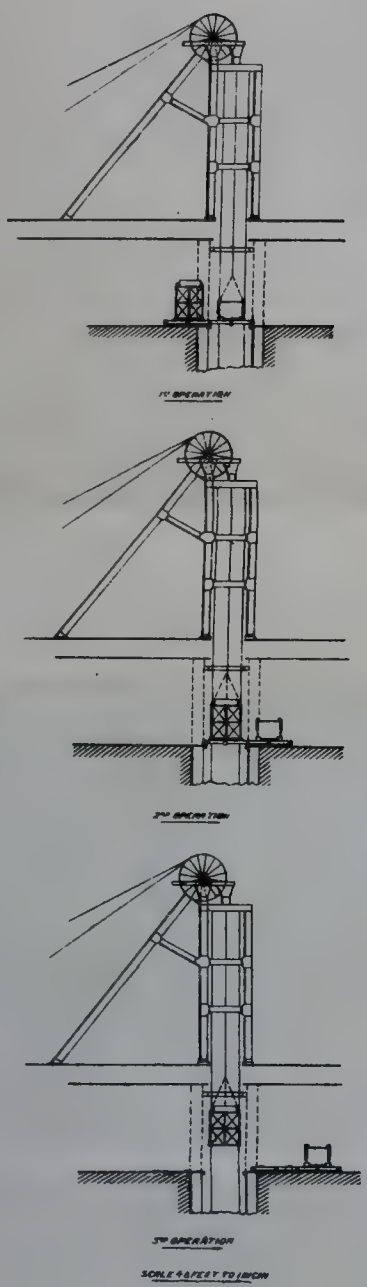
SCALE 4 OF FEET TO 1 INCH

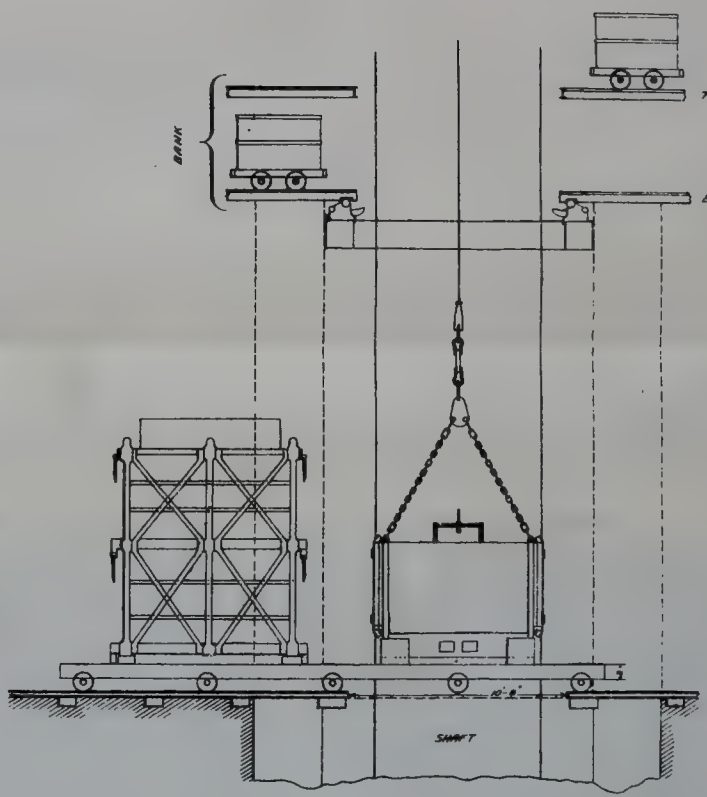


PLAN

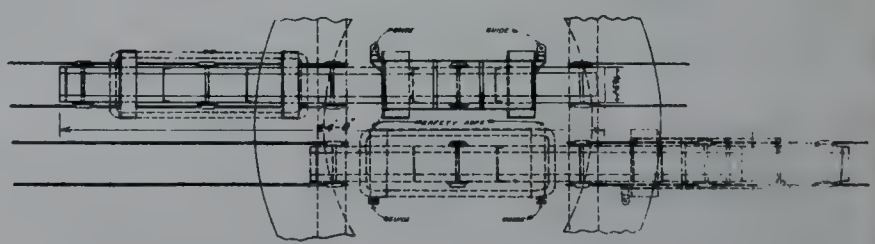
SCALE ½ INCH = 1 FOOT

RAPID CAGE-CHANGING CONTRIVANCE.





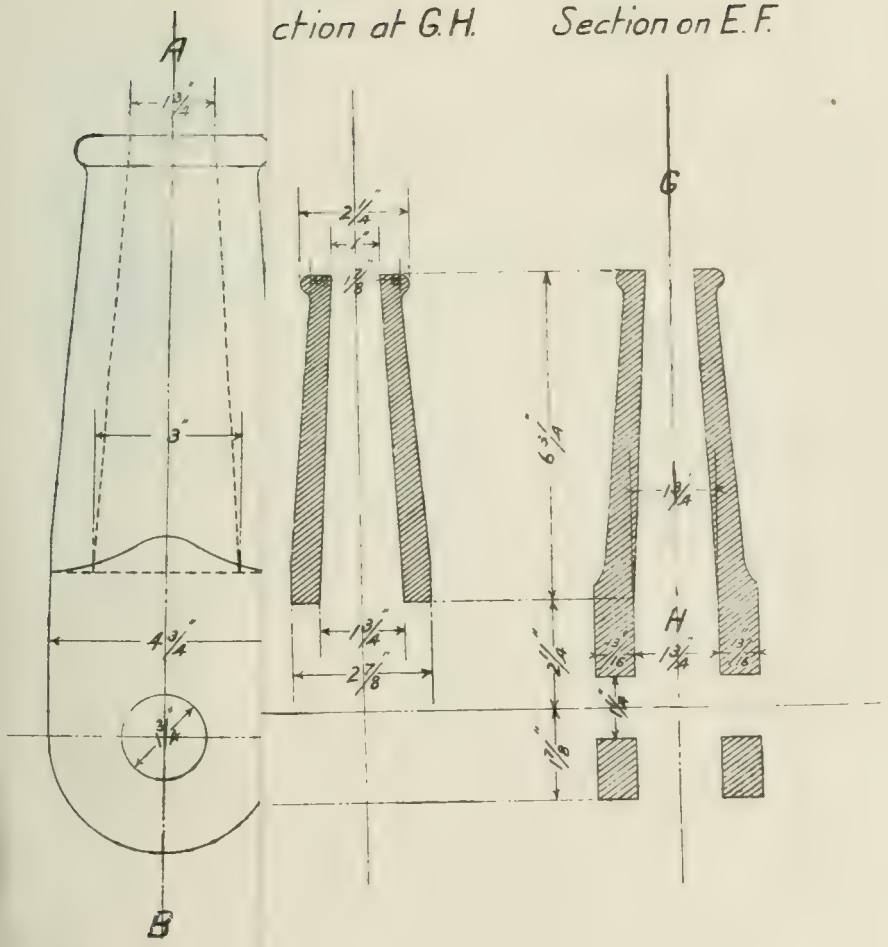
ELEVATION



PLAN

?3/4 ROPE

ction at G.H. Section on E.F.

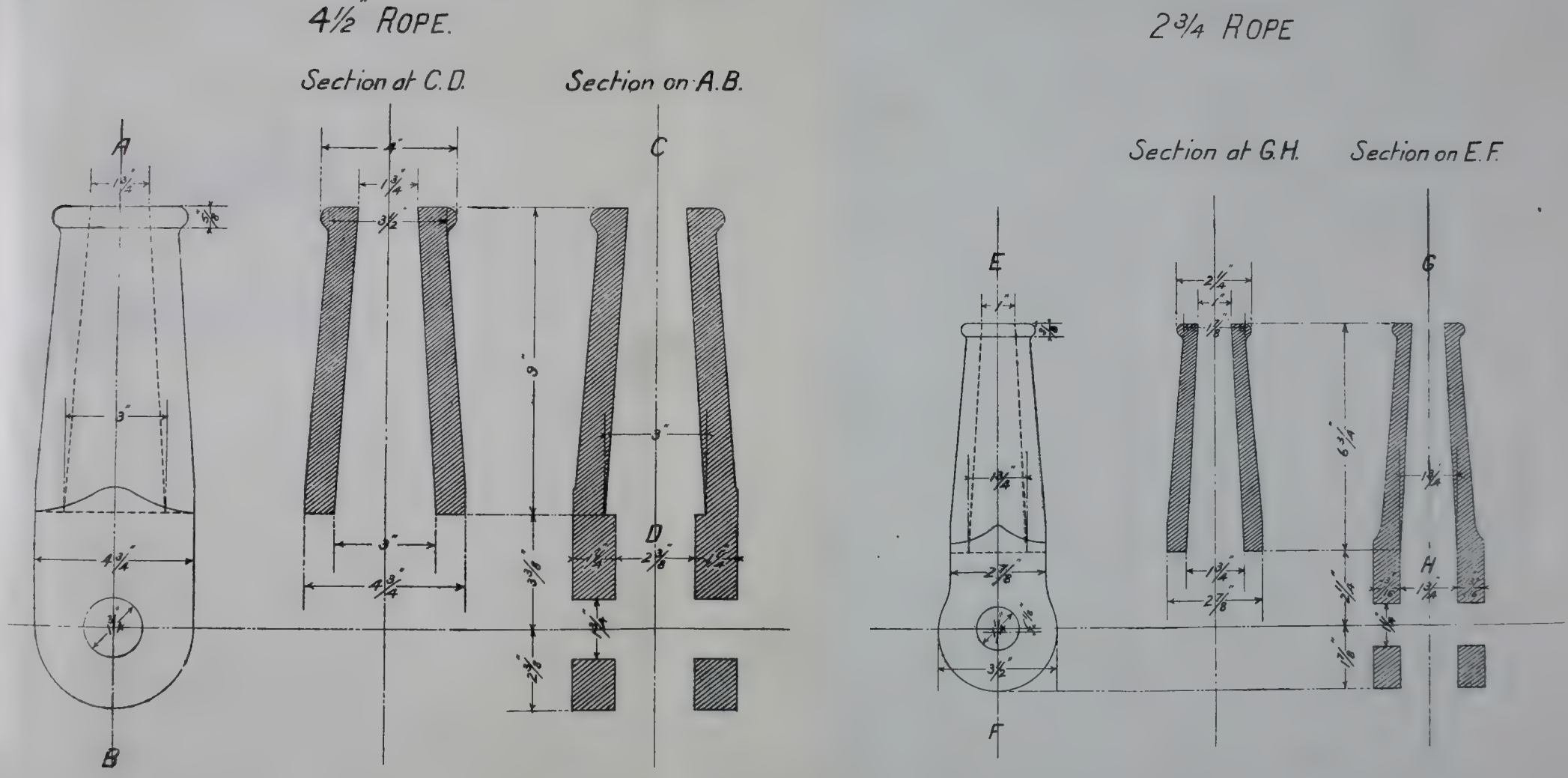


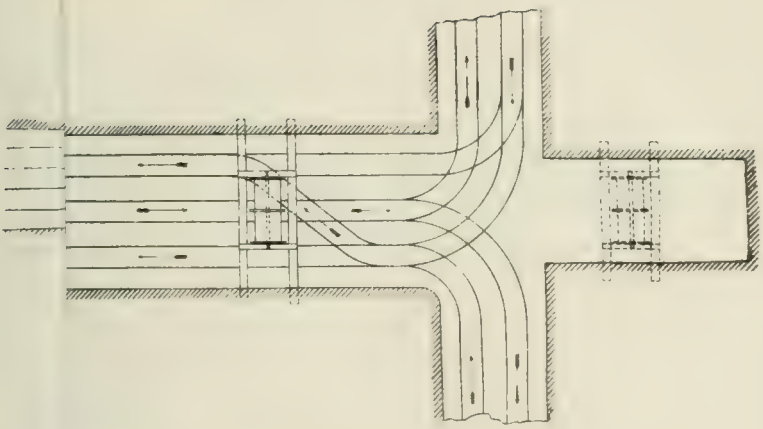
E . I . R

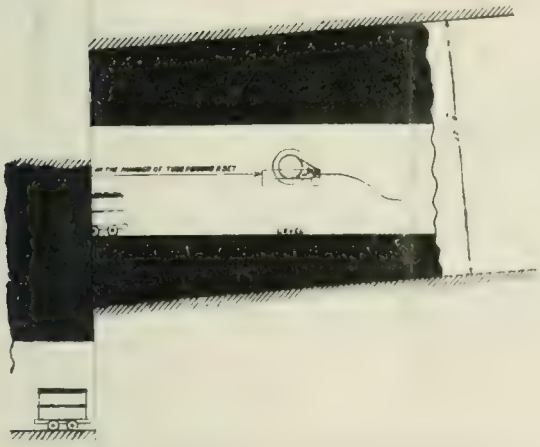
C . D

ROPE SOCKETS

QUARTER SIZE







SELF-ACTING INCLINE.

LAID OUT WITH STANDARD CAST IRON POINTS & CROSSINGS.

SCALE 1 FEET TO 1 INCH

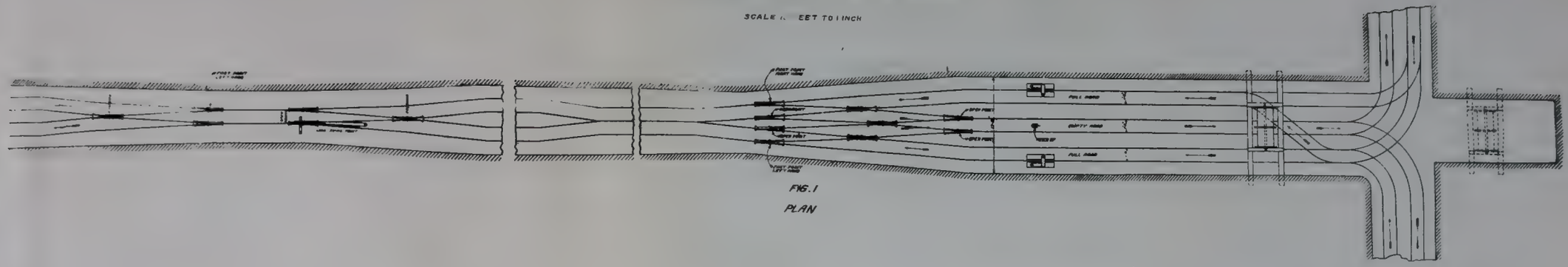


FIG. 1

PLAN

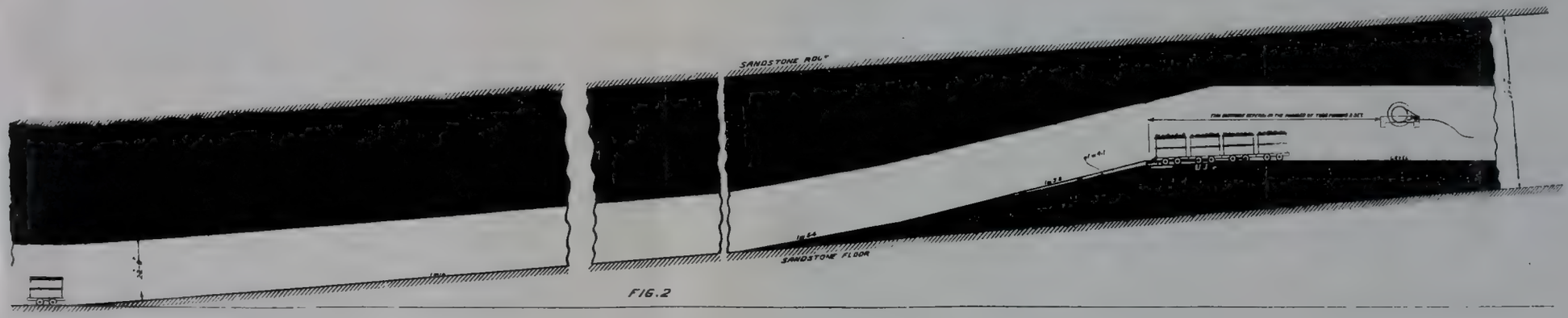
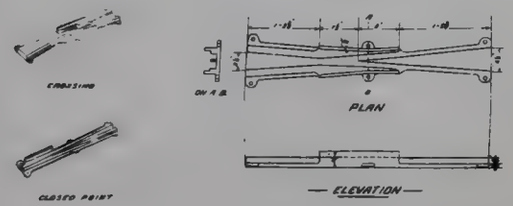


FIG. 2

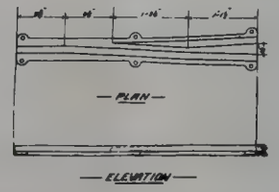
ELEVATION.

FIG 3



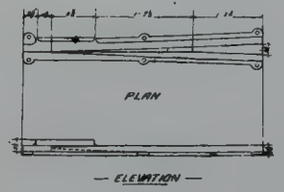
CROSSING

FIG. 4



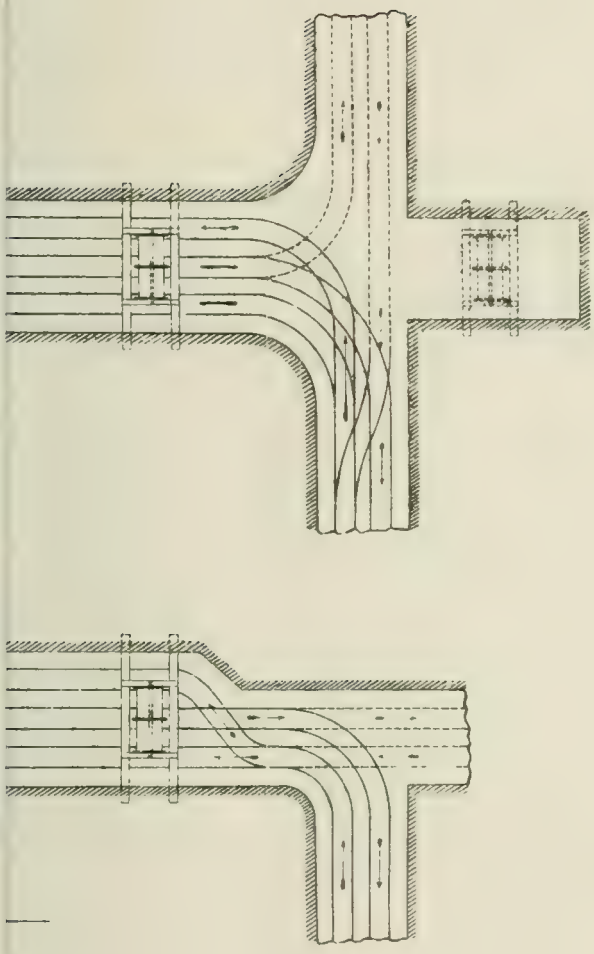
OPEN POINT

FIG 5



FAST POINT

DIVERTING TO THE RIGHT



APPLICATIONS OF THE THREE ROAD SYSTEM

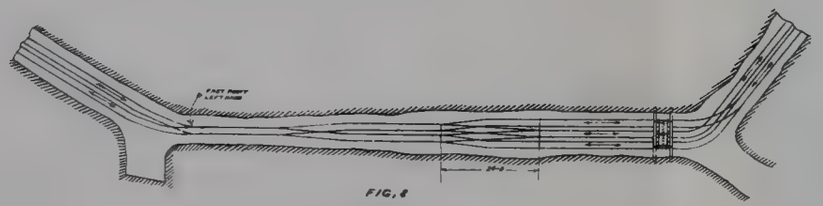


FIG. 8

NETLA PIT INCLINE.

Scale 40 Feet to an Inch

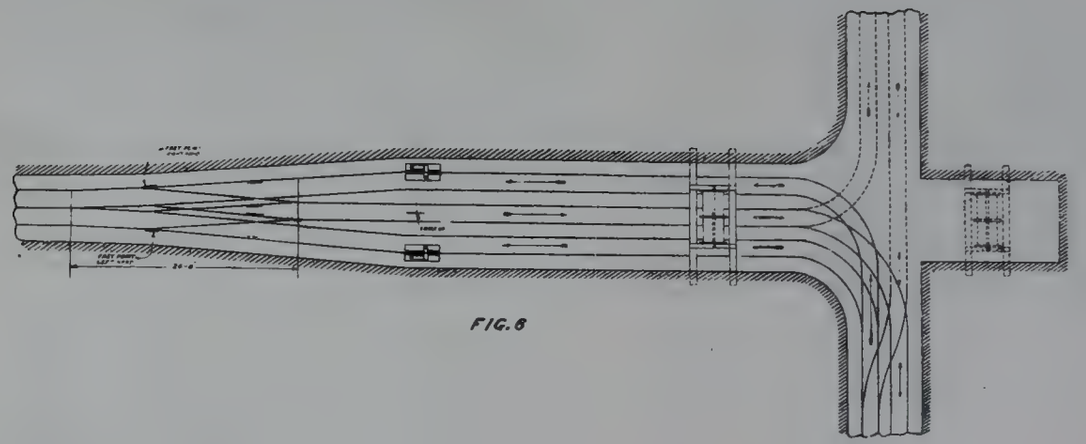


FIG. 6

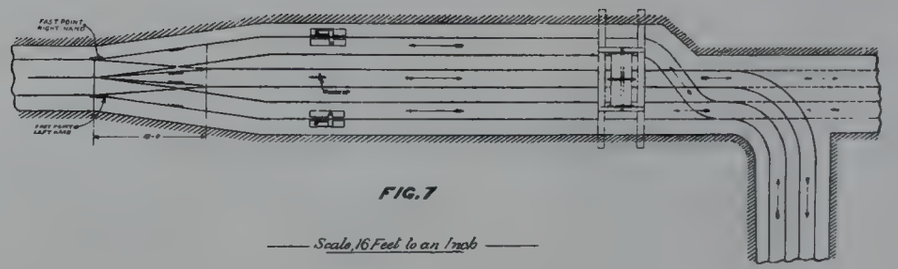


FIG. 7

Scale, 16 Feet to an Inch

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TRANSACTIONS

of the

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of

INDIA

VOL. II.

EDITED BY

THE

HONORARY SECRETARY.

CALCUTTA:

PUBLISHED BY THE INSTITUTE AND PRINTED AT THE
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1908.

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Transactions of the Mining and Geological Institute of India.

The Annual General Meeting of the Institute was held in Calcutta at the rooms of the Asiatic Society on Friday, January 26th, 1907, with the President, Mr. T. H. Holland, F.R.S., in the chair. Between eighty and ninety members and visitors were present.

The annual report of the Council was read by the Hon. Secretary Mr. W. H. Pickering as follows :—

ANNUAL REPORT FOR THE YEAR 1906.

The Council have the honour to present the first annual report upon the working of the Mining and Geological Institute of India.

1. This report covers rather more than a year, as the informal inception of the Institute took place on the 10th November, 1905. The

meeting at which the Institute was formally inaugurated was held at Asansol on Tuesday the 16th January, 1906.

2. The Institute commenced with a membership of 135, and of these 3 were ex-officio Honorary Members. The total number now is 173, made up of :—

Patron	1
Ordinary Members	156
Associate Members	8
Associates	3
Honorary Members	3
Subscribers	2

This is most satisfactory, especially in view of the fact that practically all the leading mining engineers and geologists are on the rolls, and that all important minerals and districts are represented.

3. Three general meetings were held, *viz.* :—

16th January, at Asansol.
26th March, at Barakar.
30th November, at Giridih.

The average attendance was 69. This is a most encouraging figure and will compare very favourably with the records of similar Institutes in other countries.

4. The following papers were read and discussed :—

"A Boulder Found in a Coal Seam at Sanctoria"	Mr. T. H. Holland.
"Description of the Barakar Iron Works"	Mr. W. McFarlane.
"Manganese in India"	Mr. L. L. Fermor.
"Self-Acting Inclines"	Mr. T. H. Ward.
"The Internal Examination of Wire Ropes"...	Mr. T. H. Ward.
"Notes on the Geology and Resources of the Giridih Coalfield"	Mr. T. H. Ward. Mr. T. H. Holland.

Several other important papers have been written and accepted, and will be read and discussed at subsequent meetings.

5. Two parts of the "Transactions" were issued. Part I. contains a list of officers and members; the rules of the Institute; an introduction and an account of the inauguration by the Honorary Secretary; the Presidential address and the speeches made at the inaugural dinner. Part II. contains a paper entitled "Manganese in India" by Mr. L. L. Fermor, A.R.S.M.; a number of Reviews and Abstracts of recent publications dealing with Manganese.

6. Exclusive of the meetings between 10th November and 16th January of the Provisional Committee appointed by the founders of the Institute, five Council meetings were held, the principal business transacted being—appointment of committees for special purposes, appointment of abstractors, making representations to the Government of India and Railway Companies, drafting rules and by-laws and considering applications for membership. The most important committee appointed were the Publication Committee, the Financial Committee, and the Committee for the revision of the map of the Raniganj coalfield. Mr. R. R. Simpson was appointed Honorary Secretary of the Map Committee. Considerable progress has already been made in the work of revision and in collecting information.

7. The Institute enjoyed the support of the Government of India from the beginning. His Excellency the Viceroy and Governor-General of India accepted the office of Patron. The Hon'ble Mr. J. P. Hewett, Hon. Member for Commerce and Industry; His Honour Sir Andrew Fraser, Lieutenant-Governor of Bengal, and Mr. E. H. Walsh, Commissioner of Burdwan and Chairman of the Bengal Mining Board, consented to be Honorary Members. The Council desire to record their gratitude to these gentlemen for the very active and powerful assistance they gave in founding the Institute.

8. The Government of India very generously sanctioned an annual grant of Rs. 500 to be given as a prize for the best paper appearing in the "Transactions" each year. The Local Governments are being approached with the view of obtaining their recognition and support of the Institute in some similar way.

9. At the instance of Mr. T. H. Ward, the Agent of the East Indian Railway gave the valuable concession to members attending meetings of the Institute, of travelling in a class next above the one for which the fare was paid. The following Railway Companies have also granted similar concessions, but, in some instances, the privilege has been limited to travelling first class at second class rates.

Eastern Bengal State Railway.
Bhavnagar-Gondal-Junagad-Porbander Railway.
H. H. The Nizam's Guaranteed State Railway.
Oudh and Rohilkhand Railway.
Bengal-Nagpur Railway.
Madras Railway.
Bombay, Baroda and Central India Railway.
North-Western Railway.
Assam-Bengal Railway.
Southern Mahratta Railway.

The members of the Institute have reason to be very grateful to the Railway Agents for these most generous concessions.

Gifts of books and papers for the Library were made by Messrs. P. C. Dutt and J. M. McLaren.

From the attached financial statement, it will be seen that the revenue of the Institute was Rs. 5,398-2-6, the expenditure Rs. 2,940-6-9, leaving a balance of Rs. 2,457-11-9; and that in addition Rs. 4,950, the realization of entrance fees, has been credited to Capital.

FINANCIAL STATEMENT for the year ended 31st December, 1906.

	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
CAPITAL ACCOUNT—									
Entrance Fees of 156 Ordinary Members	...	...	...	4,680	0	0			
,, ,, 8 Associate Members	...	...	...	120	0	0			
,, ,, 3 Associates ...	...	...	...	90	0	0			
,, ,, 2 Subscribers ...	...	...	...	60	0	0			
							4,950	0	0
RESERVE ACCOUNT—									
9 Life Members' subns. paid in advance	..	...	...	1,530	0	0			
1 Ordinary Member's Subn. ,, ...	...	.	...	30	0	0			
							1,560	0	0
LIABILITY SUSPENSE	...	...	...	801	12	3			
							801	12	3
REVENUE ACCOUNT—									
RECEIPTS.									
12 months subn. of 150 Ordinary Members	4,500	0	0						
6 ,, ,, 6 ,, ,, .	90	0	0						
12 ,, ,, 3 Associate Members	90	0	0						
12 ,, ,, 5 ,, ...	75	0	0						
6 ,, ,, 3 ,, ..	22	8	0						
12 ,, ,, 1 Subscriber ...	30	0	0						
6 ,, ,, 1 ,, .	15	0	0						
	4,822	8	0						
Interest from the National Bank of India, Limited	132	3	0						
Sale of Books	443	7	6						
				5,398	2	6			
EXPENDITURE.									
Advertising, Printing and Stationery .	1,407	10	6						
Postages and Telegrams	346	8	0						
Railway fares	139	14	0						
Charges, General	606	6	3						
Establishment	440	0	0						
				2,940	6	9			
							2,457	11	9
TOTAL Rs. ...	...	...	...	...	..	.	9,769	8	0

	Rs.	A.	P.
Cash with the National Bank of India, Ld.	9,380	5	6
,, ,, Honorary Secretary .	144	3	0
,, ,, ,, Treasurer ...	32	7	6
Outstanding subscriptions for 1906 ...	22	8	0
Value of Books in Stock	145	0	0
Outstanding Bills	45	0	0
TOTAL Rs ...	9,769	8	0

Examined and found correct,
LOVELOCK & LEWES,
Chartered Accountants. } *Auditors*

W. H. PICKERING,
Honorary Secretary.

R. P. ASHTON,
Honorary Treasurer.

Calcutta, 22nd January, 1907.

When the accounts had been explained by the Hon. Treasurer, Mr. R. P. Ashton, the President put them to the meeting. The report was adopted and the accounts were passed unanimously.

The President then opened and read the following :—

REPORT OF THE MEETING OF JUDGING COMMITTEE ON PAPERS.

Present.—Messrs. H. H. Hayden, G. C. Leach, G. F. Adams and E. H. Roberton in the Chair.

A letter was received from Mr. R. G. M. Bathgate, who was unable to be present, in which he expressed his opinion as to the best paper amongst those under consideration.

The papers to be considered were:—

(1) "Manganese in India," by Mr. L. L. Fermor.
(2) "A boulder found in the Sanctoria seam," by Mr. T. H. Holland.
(3) "The Barakar Iron Works," by Mr. W. McFarlane.
(4) "Waste in Bengal Coal Mining," by Mr. J. White.
(5) "The Internal Examination of Wire Ropes," by Mr. T. H. Ward.
(6) "A Rapid Cage-changing Contrivance," by Mr. T. H. Ward.
(7) "The Geology of the Giridih Coal-field," by Messrs. T. H. Ward and T. H. Holland.
(8) "Premature Explosions of Gunpowder," by Mr. J. Grundy.

The Committee resolved that, as Mr. Grundy's paper had not been received, the decision should be given on the

other seven papers. After discussing the various papers under criticism, voting took place, and was unanimously in favour of Mr. L. L. Fermor's paper on "Manganese in India."

ALTERATION OF RULES.

After scrutineers had been appointed the Hon. Secretary explained the proposed alterations of the rules, copies of which had previously been circulated, dealing with the definition of the various classes of members, associates and subscribers. Mr. W. Macfarlane desired that metallurgy should be more definitely included as a qualification for membership, and Mr. H. G. Graves thought that some limitation should be placed on the time or conditions for which subscribers should enjoy the privilege of membership. Finally, it was resolved that the matter should again be referred to the Committee for such verbal or other alterations as were considered requisite, and that the rules should then be circulated.

ELECTION OF PRESIDENT, ETC.

Mr. S. Heslop and Mr. H. C. Veasey, who had been appointed as scrutineers to deal with the voting papers for the election of the President, Officers and Council for the year 1907-1908, reported that the following gentlemen had been elected:—

President.—Mr. T. H. Holland, F.R.S.

Vice-Presidents.—Messrs. P. Bosworth-Smith and T. H. Ward.

Honorary Secretary.—Mr. H. G. Graves.

Honorary Treasurer.—Mr. R. P. Ashton.

Council.—Messrs. G. F. Adams, E. C. Agabeg, F. J. Agabeg, R. G. M. Bathgate, R. J. Browne, W. H. Clark, H. H. Hayden, H. H. McLeod, W. Miller, W. H. Pickering, Chas. H. Richards, Thos. Richards, G. F. Scott, A. S. Thomson and R. Wordsworth.

A vote of thanks to the Council and officers for their services during the past year, moved by Mr. H. G. Graves and seconded by Mr. H. H. Hayden, was adopted with acclamation.

The President then delivered an address as follows :—

Presidential Address.

BY

T. H. Holland.

Introduction.

While acknowledging, on behalf of my fellow-members of Council, the vote of thanks so cordially adopted by the meeting, I think my colleagues will readily permit me to say that we owe to Mr. Pickering, the founder of the Institute, the conspicuous success that has attended our first year's work; and as this is the last, as well as the first, of our Annual Meetings which he is likely to attend, on account of his decision to revert to the Home service, I should like the privilege of proposing Mr. Pickering's name as the first of our Honorary Members.

The Relationship of Pure to Applied Science.

In the address delivered at the Inaugural Meeting of the Institute last year, I took as my text the second of our constitutional rules defining the objects of this Institute. It was then explained, also, that the closely related Geological Survey of India was established by Government with the object of developing our mineral resources.

For endorsing these and like sentiments, I have been reminded by certain scientific friends that the position stated needs a certain amount of qualification, more than one having taken me to task for appreciative quotation of the sentiment that "the great end of life is not knowledge but action." I have forgotten now where the formula came from, but it

sounds much like a paraphrase of Carlyle's dictum, "The end of man is an action, and not a thought, though it were the noblest."

Obviously this is not a suitable occasion for a dissertation on moral philosophy; but it is necessary, even from the most practical man's point of view, to consider at times how far our work in India is in danger of deterioration from enforced and continuous action in a country where there is so much to do and so few to do it.

If I spent my allotted hour in tracing the utilitarian doctrine from its probable source in the rank hedonism of the philosopher of Malmesbury, through the succession of more modern philosophers, like Bentham, Mill and Bain, you would justly charge me with neglect of my own proposition; of discussing the theory when its application is our present concern. But those who entertain any doubts as to my orthodoxy will perhaps be satisfied if I express adherence to the following statement of one who cannot, at any rate, be suspected of entertaining an insufficient appreciation of the intellectual value of scientific research.

In a lecture on the study of biology, delivered just thirty years ago, Professor Huxley, in endorsing Hobbes' assertion, "that the scope of all speculation is the performance of some action or thing to be done," continued:—

"I have not any very great respect for, or interest in, mere knowing as such. I judge of the value of human pursuits by their bearing on human interests; in other words, by their utility; but I should like that we should quite clearly understand what is meant by this word "utility." In an Englishman's mouth it generally means that by which we get pudding or praise, or both. I have no doubt that is one meaning of the word utility, but it by no means includes all I mean by utility. I think that knowledge of every kind is useful in proportion as it tends to give people right ideas, which are essential to the foundation of right practice, and to remove wrong ideas, which are no less essential foundations and fertile mothers of

every description of error in practice. . . It is not only in the coarser, practical sense of the word "utility," but in this higher and broader sense, that I measure the value of the study of biology by its utility."

It was Emerson who said that it is hardly possible to state any truth strongly without apparent injustice to some other truth, and in reminding you of our primary duty to the country, there was no intention to imply that the geologist, who never sees an economic return for his work, contributes less than the prospector towards the progress of the country. It is obviously not to my own comfort, or that of my colleagues, to curtail that section of the work which is the hobby of most of us.

We have developed a habit of calling a man scientific when the materials he handles are microscopic sections, fossils, stars, deep-sea fishes, or germs; the less marketable his products the more scientific the worker in the popular estimation. As a consequence of general unfamiliarity with the materials with which the so-called scientist deals, he has been alternately looked upon as a harmless lunatic or treated as a *jogi* because of his desire to know things that are of no apparent practical value. He has probably not deserved as a class the full share either of ridicule or of reverence which he has received. It is difficult for us now-a-days to appreciate the state of public feeling in the days when Swift's satires at the expense of the Royal Society, in Gulliver's introduction to the academy of Lagado, could be regarded by educated people as tolerable literature; or still earlier, when the celebrated Dr. South could with impunity describe the members of the Royal Society as incapable of admiring anything "except fleas, lice and themselves."

Yet there is a remnant of this idea still in existence: the boy who goes out of the public school seldom sees any connection between the science he is taught and the profession

to which he is subsequently apprenticed, because the Science Master has, as a rule, no practical acquaintance with the industrial aspects of the sciences he teaches, being generally more in touch with the professors of the so-called sister sciences than with the captains of industry. The separation of the two classes, now distinctly less pronounced, fortunately, than formerly, is not due to the mere grouping together of similar tastes, but is a relic of the time when it was necessary for scientific men to gather together in self-protective guilds.

Science has been defined as "nothing but trained and organised common sense": the prominent difference between ordinary and so-called scientific knowledge being the sporadic character of one and the systematic character of the other—the systematic observation of facts, their grouping into classes of like kind, the drawing of deductions from established propositions and their verification by experiment or observation. These are the methods of science; but they are by no means the monopoly of the man who deals with biological, mathematical and astronomical problems. The scientific method is just as necessary, and is just as often employed, in industrial affairs as in matters of no economic importance.

It may be contended that the industrial and business man necessarily applies science for personal profit, preventing the public from benefitting fully by his inventions through patent protection. But, alas! the history of science is also stained with disputes just as sordid on questions of priority and credit. One is after the "pudding" and the other the "praise." Which is the most worthy?

One has only to glance back over the history of science to see how certain branches, requiring little or no assistance from the arts, reached a high degree of development in early times, while others remained in the most primitive condition

until recent years. This irregularity of progress among the sciences continued until the beginning of the XIXth century, when it was suddenly found that the discoveries of science had a direct bearing on the industries which were hitherto conducted by rule o' thumb. Immediately after the two came into touch, the progress of both went on at an unprecedented rate. It is extraordinary that the remarkable work of Galileo, Newton, and of the great men who followed them, remained of mere book value for more than 150 years. Obviously the interests of science and industry are bound together; each advance of science is followed by new developments of industry, and, at the same time, industrial progress facilitates in endless ways the means for scientific research. If I were asked to name the real landmarks in scientific progress, I think I should name such inventions as the safety lamp, the steam-engine, and the electric telegraph rather than the atomic theory, the quantitative law of electrolysis and the mechanical equivalent of heat. It is all very well to say that the formulation of great scientific laws leads to innumerable results of value, economic and academic; that is true enough, but unfortunately we more often discover explanations of results blundered on accidentally, rather than laws to guide one to results.

One of the first principles taught by the professor of science is the advantage of a *natural* system of classification amongst the materials with which his subject is concerned. The closer a system of classification approaches a formula for expressing natural relationships, the greater its efficiency as an instrument of research and as a guide to profitable deductions. Conversely, whilst an artificial division of materials and phenomena may not retard the accumulation of facts, such a system remains sterile as regards philosophic progress.

Now I have attempted to show that the grouping together of those engaged in the problems of theoretical, so-called scientific, value with those engaged in the practical application of the same science, is a more natural form of classification than the grouping together of representatives of the various pure sciences, and their separation from technical and business men. Neither the methods nor the facts of science are the exclusive property of one class, and the division-line between scientific and industrial is now approaching obliteration.

Functions of a State Geological Survey.

I have discussed in general terms the attitude of the scientific man towards economic problems, because the question has a direct bearing on the principle which governed the foundation of this Institute, and affects the policy of the Geological Survey for which I am at present responsible. The aims of the Institute I discussed last year, and I propose now to explain briefly the way in which the Geological Survey can best serve the interests of geology; in what directions and how far its functions extend beyond the immediate requirements of pure science.

An examination of the laws establishing the State Geological Surveys of practically every country in the world will show that they were founded with an object precisely similar to those that gave birth to this Institute and our Geological Survey. The law-givers may have been wrong in being guided by purely utilitarian motives: there is room for more than one opinion on this point; but they at least have the right to determine the disposal of the tax-payer's money, and the Director of a Geological Survey has no more right to utilise his position for any purely scientific hobby

of his own than a sporting revenue officer has a right to spend the collected taxes on race-horses.

Whether, therefore, we like it or not, the official geologist in this country is bound by the terms of his appointment to remember, that, either directly or indirectly, his work should aim in the long-run at the development of our mineral resources. Our chief difficulty is to determine where official research should end and private enterprise begin.

Before mineral prospecting operations can be planned, it is necessary to prepare a geological map showing the general relations of the chief rock-groups in the area concerned. As such systematic work in one area permits the formulation of general rules for the solution of similar problems in other parts of the same country, it is obvious that the preparation of the general geological map is the duty of an agency that is free to publish its results for the benefit of the general public ; in other words, a Department of the Public Service. During the preparation of a general geological map, it is found that certain areas offer results of greater value than others, and these consequently are marked out for more detailed study ; some of these offer results of unusual interest in their bearing on current scientific doctrines ; others are important because of the occurrence in them of minerals known to be of economic value, and it is in dealing with the latter that we come into contact with the daily recurring problem of where the duties of a public agency end. In a country like India, where the Imperial Government and many States are large owners of mineral rights, and where certain public bodies, like railway companies, are guaranteed by State funds, the degree to which the Geological Survey operations are carried may sometimes pass beyond the exploratory stage, and must, naturally, vary greatly with each particular instance.

But in general the field-work of the Geological Survey ends with what is known as the exploratory stage as regards minerals of economic value; that is, the stage at which sufficient information is obtained to warrant the outlay of money for systematic prospecting operations. The official operations normally end with the publication of the information available at this stage; but the Geological Survey still takes an interest in the work of prospecting and exploitation, for it is responsible to advise Government with regard to the conditions under which concessions are granted to miners, and has also the duty of summarising the statistics of production and of pointing the lessons to be learnt therefrom. Every year a paper is published in the Records of the Geological Survey giving a summary statement of the previous year's mineral production, and a list of the concessions granted in the areas within which Government owns the mineral rights; every five years a review of the progress made during the longer period is published for general information.

Although a Geological Survey has nothing to do with the actual work of mining, it is necessary for it to maintain an intelligence branch capable of making a general statistical survey of the industry; for the economic minerals of value in one place may have no value in another, and their values in the same place naturally vary with changes in the markets and developments in the means of transport. To direct our researches into the most profitable channels, therefore, it is necessary for the geologist to keep in touch with the mining industries.

Much of the work that precedes the establishment of a so-called "prospecting proposition" has no apparent direct bearing on economic questions, and may appear to be of purely academic interest. As you will see from a paper to be published this year, the Geological Survey Department have

made three special attempts recently to settle the precise age of the base of our Gondwana system, and at last, through the energy of Mr. H. H. Hayden, the question that has been the subject of such controversy in the past is now settled by positive evidence. It is possible that there are some among those who obtain their living from Gondwana coal who do not care whether the Damudas are Palæozoic or Mesozoic according to the European standard scale of strata, and do not consequently see the value of worrying about the precise age of the rocks. It is quite possible also that our latest discovery may never affect the local or any coal market; but I know for certain that it will be of interest in the wider market of intellectual products, and thus, judged by its market value alone, Mr. Hayden's discovery becomes an economic product.

The question of the dual relationship of a National Geological Survey to mining and geology, gave rise to an interesting discussion at the Annual Meeting of the Canadian Mining Institute at Quebec on the 7th March, 1906. The Secretary of the Institute appeared to express the general opinion of the members in a paper describing the history of the Geological Survey of Canada and of the recently created Mines Branch of the Department of the Interior.[1] The Canadian Geological Survey was founded in 1843 under the directorship of Sir William Logan, who referred to the aims of the new Survey in the following communication to Sir Henry De la Beche:—

"The main object of the survey is to ascertain the mineral resources of the country, and this is kept steadily in view. Whatever new scientific facts have resulted from it, have come out in the course of what I may

[1] H. M. Lamb. On the advisability of the establishment of a Federal Department of Mines. *Journ. Can. Min. Inst.*, IX, 1906, 87.

conceive to be economic researches carried on in a scientific way . . . . My whole connection with geology is of a practical character."

In 1890 the Canadian Government passed a new Act setting forth the following among the duties and objects of the Geological Survey :—

To make a full and scientific examination of the geological structure, mineralogy, mines, and mining resources of Canada. . . .

To maintain a museum . . . . for exhibition of such specimens as are necessary to afford a complete and exact knowledge of the geology, mineralogy and mining resources of Canada.

To collect and publish full statistics of the mineral production and of the mining and metallurgical industry of Canada ; to study the facts relating to water-supply . . . . and of mines and mining work in Canada."

Although this Commission appeared to be wide enough to cover the whole realm of theoretical and applied geology, in 1902 the Dominion Government established a Mines Branch in connection with the Department of the Interior, and the memorandum laying down the lines on which the new Department should work was merely an elaboration of the provisions for economic work in the Geological Survey Act. In his paper, Mr. H. M. Lamb points out that, with the exception of experimental metallurgy, every line of work, which is set forth as within the purview of the Mines Branch, has already been taken up, or is now being prosecuted, by the Geological Survey of Canada. He argues that

"given a properly reconstructed Geological Survey, of which the Mines Branch might form a part, it could employ the same extra grant with at least equal economic efficiency. Such work of the highest quality is being carried out on an enormous scale by the Geological Survey of the United States . . . . The work done by this Survey has so emphatically commended itself to the mining interests in the neighbouring Republic that the Government have repeatedly extended the scope of the Survey and greatly increased the sum appropriated for its use. The mining industries of Canada might at the present time be greatly assisted if the work of the Geological Survey and the Mines Branch of the Department of the Interior was taken up

seriously by Government, correlated, systematised, extended, and made to conform to modern requirements. The duplication which now exists would thus, in the interests of economy, be avoided . . . . All Canadians would be sorry to see the Geological Survey of Canada lose its independent existence . . . . but if the happy result above indicated could be insured by the appointment of a Minister of Mines who would have direct supervision of the work, the expansion of the Geological Survey into a Department of Mines and Geological Survey would receive the support of the whole mining community."

The Relations of a Geological Survey to Education.

The great variation in personal idiosyncrasies make it impossible, naturally, for every geologist to follow his subject into all its human bearings; but a body of geologists, large enough to include various temperaments, should be so organised that every direct relationship of the science to human affairs should come within its scope. In addition, therefore, to its research work in scientific and economic subjects, the functions of a Geological Survey Department should extend to education, not only in its limited sense as represented by the ordinary University, but also for the wider public in organising museum collections.

Both these functions have been carried out to a certain degree in India: those of you who visit the Museum this afternoon will find the Geological collections under the same roof as Zoology and Archæology, with no superficial indication in the management and arrangement to show that the Geological section is distinct from the rest of the Museum. It is, however, a product of the Geological Survey and has been always under its control, while the Archæological, Zoological, Industrial and Art collections are grouped together under an independent body of Trustees.

In the work of teaching, the Geological Survey has taken a smaller part. Courses of lectures have been delivered

by one of the officers in the Presidency College during the past twelve years, and a certain number of students and apprentices have received a post-graduate training at the headquarters' office as well as in the field. It is this section of the work that I think should be developed still more, and made systematic enough for the grant of diplomas. For the good of the teachers as well as the taught, I should like to see practical assistance in education regarded as one of the essential and regular duties of all the technical and scientific departments in India.

But we have suffered here, as they have suffered in other countries, by an unnatural system of classification which places the theory and methods of teaching in advance of practical acquaintance with the subject taught, the system being a survival from the time when the schoolmaster was supposed to be able to teach enough of the limited number of subjects considered to be sufficient for a student's education, and when education was not supposed to have a direct effect on professional work in after-life.

The effect of our educational policy in India on a race whose instincts are naturally more philosophical than material, has been the production of an unlimited supply of able politicians, fertile journalists and excellent lawyers, but an insufficient number of workers able to render real assistance in the great *swadeshi* movement of which we have heard so much of late, as if it were some newly-discovered law in political economy, instead of the perpetual policy of Government.

A few more practical men among our so-called educationists would teach the latter that pruning and grafting are as essential sometimes as stimulating fertilisers. Possibly more good has been done than is generally recognised, though perhaps by accident, in forcing the practically-minded

English boy to pass through an apparently useless drilling in classics ; but that which may produce fruit in the boy who makes his own ships and rabbit-hutches, may cause an undesirable tendency to run to literary stalk and leaf in the boy whose inheritance is an unpractical nature. It is not surprising, therefore, that the work of the English educationist in this country has resulted in "nothing but leaves." If one judged always by the results of education in India, one would be tempted to apply the cynical maxim of Bernard Shaw's revolutionist : "He that can, does : he that cannot, teaches."

Let me remind you that our second rule provides for the dissemination as well as the accumulation of the data which are necessary for developing our mineral industries, and I take it that the absence of a class of technically efficient assistants, due partly to inefficient educational methods, is at present our chief handicap. If I am right in assuming that our Universities ought to take more practical interest in the industrial side of India, we ought to insist on the industries being represented more fully in the councils of education. At present the combined science and industry embodied in this Institute has but one representative on our five University Senates, and he is but a geologist. I would suggest, therefore, as one of the duties of this Institute, that this deficiency, which is probably a mere accident, be brought at once to the notice of Government.

The Development of Indian Metalliferous Minerals.

I will pass on now to a question of more immediate interest to practical men ; that is, one having a more direct bearing on the "pudding" section of utility. When I returned to India a little over three years ago, some of our leading coal-mine

owners in Bengal were in a state of ferment on account of the rumour that the Government were contemplating the institution in other provinces of boring operations for coal. In order to prevent my support to this untoward development of swadeshism, I was supplied with artistic details of the terrible hardships that would be suffered by that down-trodden but worthy class of workers, known as Managing Agents, if the Government encouraged competition with the Bengal coal-trade. It was partly due to arguments of the kind then pressed so eloquently that I thought it advisable to adopt no more aggressive policy than marking time until a statistical survey could be made of recent progress in the Indian mineral industries. The results of that survey have been issued in the form of a special review,[1] and my conclusions agree in general with the disinterested arguments of our Calcutta friends in showing that the coal-consuming minerals require more assistance than coal.

The most conspicuously weak feature in our mineral industries is a replica of the dangerous spots in the trades dependent on vegetable products. The trade of India, like that of tropical countries generally, has been for the most part a simple exchange of those materials produced easily and cheaply under the conditions of rapid reproduction in a tropical climate, for the manufactured and artificial products of more highly developed countries in Europe and America. It is essentially a primitive form of trade, practically a barter, between two countries utterly unlike in their natural conditions and products; the majority of the minerals raised are either consumed by what elsewhere[2] I have termed direct processes, or, with further disregard to the laws of political

[1] *Rec. Geol. Surv. Ind.*, Vol. XXXII, Part 1, 1905.

[2] *Rec. Geol. Surv. Ind.*, XXXII, p. 8, 1905.

economy, are straightway sent of the country in a raw state.

Obviously, therefore, they are not being turned to the most profitable account possible, as we have to pay the smelters' and carriers' profits, and to import again many of the constituents of the exported minerals in the form of manufactured metals and chemicals. The exporters of vegetable raw products have the satisfaction of knowing that they can rely on the unlimited reproductive power of a tropical climate, and have to fear only the competition of cheaper artificial substitutes, or the opening up of other tropical countries. The miner has these dangers to face also, but with the additional knowledge that his property is a depreciating concern from the commencement of exploitation ; it is advisable, therefore, to make the most of our mineral products before they are lost.

The minerals raised have been, like the vegetable products, those that by chance occur so abundantly and cheaply that their local value is less than the cost of their freight from foreign countries. The deposits now being worked are so few compared to those known to exist in the country, and the value of the minerals raised is so small compared to our charges for imported mineral products, that no one could be satisfied with even the comparatively rapid progress recently made in India. Practically nothing is being done to work most of the metalliferous ores that contribute so largely to the wealth of countries like England, where the metallurgical industry forms the nucleus of a great web of trades.

There was a time when India occupied a prominent place in the metallurgical world, when smelters of iron and steel and artistic workers in copper and brass flourished in the country. To-day the manufacture of iron by the primitive *lohar* is restricted to areas far removed from the railways

which distribute the imported foreign article ; no lead-mining now exists in the country ; copper and brass-wares are made entirely from imported materials, and every attempt to work the known copper-deposits has come to grief. The primitive chemical industries, like the manufacture of alum, the various alkaline compounds, blue vitriol and copperas, have been all but exterminated through the imports of foreign materials, which are not only cheaper, but can be depended on for uniformity of quality ; and it is uniformity and reliability of quality rather than average superiority that has contributed more than any other feature to give the foreign article an advantage over the indigenous product.

I do not propose to inflict on you a long sermon on the possibilities and difficulties of a general industrial revival in India : we have heard enough vague statements about that question lately ; but I will content myself with drawing your attention to certain features in our present knowledge which indicate the possibility of developing some of our much neglected metalliferous deposits—a subject that should be of immediate interest even to our coal-mining members who hold the chief supplies of the necessary power.

During recent years the conditions essential for a revival of certain metallurgical industries in India have shown considerable development ; but before referring to a few of these, it may be desirable to remind you of some of the stumbling-blocks in the way.

First of all, for the economical development of many metals operations must be conducted on a scale large enough to reduce the inevitable general charges to a small fraction of the total, and in many cases, a profitable margin is possible only when the operations are large enough to permit of the recovery of the smaller among the by-products.

Secondly, before accepting the figures which gauge the

total capacity of the Indian market, it is necessary to know whether the whole of the products can be absorbed in the more limited market within striking distance of the works.

Then there is another standing difficulty, too often overlooked by the enthusiastic promoter. At all the ports in India, as in other countries, there are the indispensable merchants, who import and distribute foreign-made metals; and, before similar facilities are obtainable for the distribution of any newly-made indigenous product, it is necessary to obtain their good-will. It is perhaps unnecessary to remind you that no one has so far invented a recipe for diverting the good-will of a really trustworthy commercial agent other than by an increase of his commission.

The various failures which have followed numerous past attempts to work our metalliferous ores may be regarded in two lights according to our temperaments. There are some who would consider that our copper, lead, tin and iron deposits have now been sufficiently tested, the repeated failures demonstrating their worthless character. There are others who may regard the many failures as so many warnings of what to avoid in future enterprises, and to these optimists, the more the failures, the nearer we are towards eliminating all but the one road to success. The practical few who lie between these two extremes will endeavour to find out if the causes which led to failure are inevitable or removable, temporary or permanent, and whether any changes have occurred lately in the general economic conditions that affect the problem.

My position would be intolerable if I attempted to give the public the results of my confidential access to the data by which certain of these failures can be correctly analysed and placed. I will therefore call your attention merely to some of the conditions which have so far changed that the

proposal to develope certain of our known metalliferous deposits is now in a more favourable position than it has been during the past thirty years in which our most serious failures have occurred.

The first change in the general conditions obviously important is the increased demand shown by the expansion of our imports of the metals. During the year 1906 the imported metals were valued at $7\frac{1}{4}$ million sterling, plus the still higher amounts for imported machinery and railway plant, which have values naturally greater than those of the mere metals used in their construction.

The second important feature contributing to the favourable character of present prospects is the recent general rise in the prices of metals, as gauged by a gold standard. The recent rise in prices has varied in the case of each metal, although there is naturally a sympathetic variation in price among those that are capable of replacing one another in the Arts. The *apparent* rise, also, is in excess of the *real*; for there is a general, though not uniform, rise, which consequently involves a depreciation in the purchasing power of the gold standard. It is advisable to deal with this subject cautiously, as I am aware that equally good authorities, with equally reliable data, handled with absolutely logical severity, can come to opposite opinions on this question of the value of a currency-standard. I hope it will be allowed, however, that, as there has not been a similar rise in the prices of those substances in which increased demand can be answered readily by increased output, gold has not depreciated in purchasing value to the full extent indicated by the extraordinary rises in the prices of metals like copper, tin and antimony.

The diagrams exhibited to represent graphically the tables printed in the text, will demonstrate the changes that

have occurred in the average annual prices of the principal metals during the past few years, and the average monthly prices during the last two years in which the principal changes have occurred. Time will permit me to deal briefly with one or two of the metals only.

Copper.

The increase in the value of copper is perhaps the most striking among the metals used on a large scale, and in this case there is little doubt that the rise in price is mainly due to the way in which demand, especially in consequence of electrical developments, has outstripped the visible supplies. Tables 1 and 2 show the way in which the price of copper has varied during the past twenty years, while a reference to fig. 1 will show that there has been at the same time a steady increase in production. These figures should be taken into account by those who failed to make profit out of the mines of Baragunda and Rajdoha when, in the early nineties, copper was less than half its present price; but it is necessary also for those who accept the favourable reports that have been made on these properties to take into account the probable trend of the copper market.

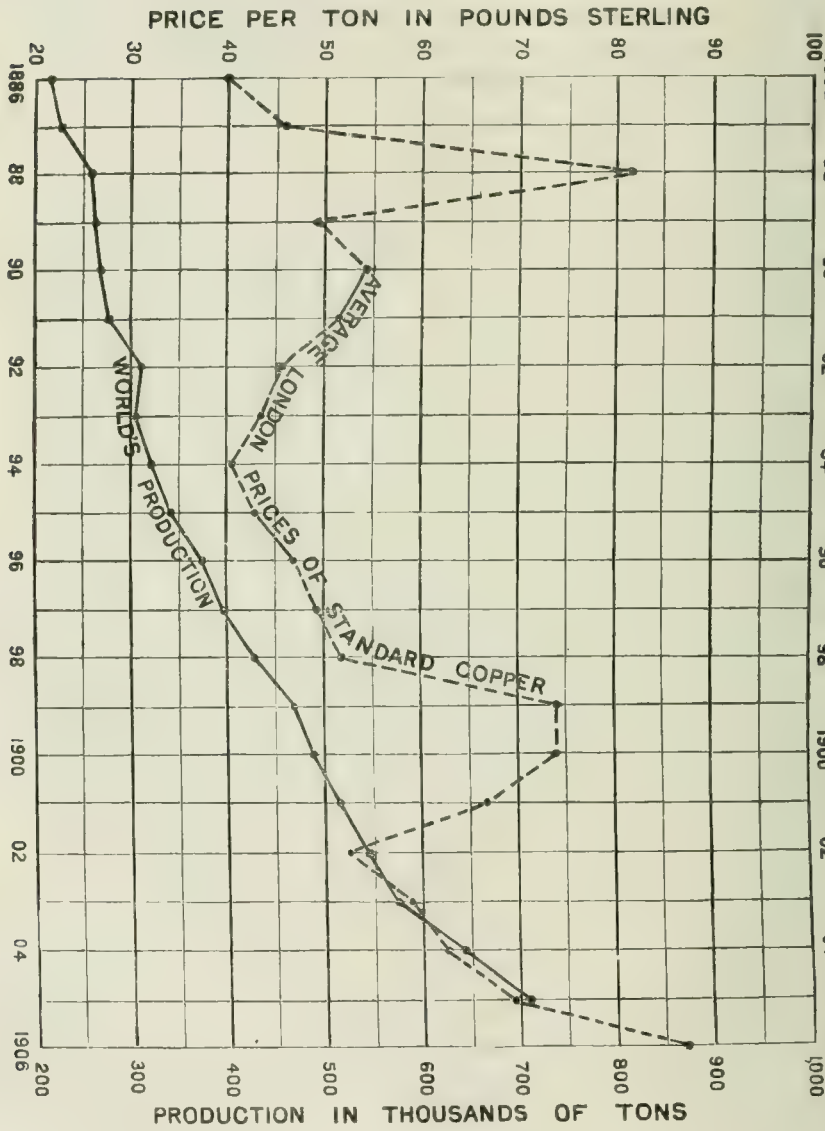
PRICE PER TON IN POUNDS STERLING
20
30
40
50
60
70
80
90
100
1886
88
90
92
94
96
98
1900
02
04
1906
AVERAGE LONDON PRICES OF STANDARD COPPER
WORLD'S PRODUCTION
200
300
400
500
600
700
800
900
1,000
PRODUCTION IN THOUSANDS OF TONS

TABLE 1.—*Average Annual Prices of Standard Copper in London for the past 20 years.*[1]

YEAR.	STERLING PRICE PER TON.			YEAR.	STERLING PRICE PER TON.		
	£	s.	d.		£	s.	d.
1887	46	0	6	1897	49	2	6
1888	81	11	3	1898	51	16	7
1889	49	14	8	1899	73	13	9
1890	54	5	3	1900	73	12	6
1891	51	9	4	1901	66	19	8
1892	45	13	2	1902	52	11	5
1893	43½	15	6	1903	58	3	2
1894	40	7	4½	1904	62	12	2
1895	42	19	7	1905	69	9	2
1896	46	18	1	1906	87	5	8

It will be noticed that between 1887 and 1898 the price of standard copper ranged between £40 and £54 a ton, except in the year 1888, when, through the famous Secretan speculations, the average price for the year went over £81, and during the year reached at one time as much as £100 10*s*. Since 1898 the price has shown a tendency to keep to a higher level, reaching its maximum in the year just closed.

In speculating as to the possible demand in future for copper, one has to take into account the fact that its use has

[1] From the Copper Handbook by H. J. Stevens, except for 1906, which is taken from the returns published in the Eng. & Min. Journal.

been largely stimulated by the electrical developments of the last 25 years. Before 1880 the average rise in the production of copper was under 4 per cent. per annum; for the next 20 years it was over 4 per cent., and during the past 5 years the increase has reached 8 per cent. If this rate continue, there will be over a million tons of copper produced in 1910. To predict a favourable future from an uninterrupted development during the recent past may be regarded as a reasonable risk, unless the chief contributors to the increased demand for the metal are likely to be superseded. The extension of electric power being the chief cause of the increased demand for copper, we should be safe in assuming that this source of consumption will expand with the opening up of so many new lands, in which up-to date industrial methods are being introduced. There is also no present prospect of copper being replaced on a large scale by any other metal in electrical works; and one may assume, therefore, that the demand for copper is likely to keep pace with the supply; indeed, many authorities in a position to judge are of opinion that the new mines being opened up, and abandoned workings being revived, will not be sufficient seriously to disturb the markets that are growing so rapidly.

Beside these general considerations as to the probable permanence of the chief demand for the metal, we should take into consideration the way the market has fluctuated during the last two years in which the main rise has taken place. The average monthly prices given in table 2 shows that this rise has been on the whole steady, and therefore not due to artificial forcing through speculation.

TABLE 2.—*Average Monthly Price of Standard Copper in London during 1905 and 1906.*[1]

	1905	1906
	£	£
January	68·262	78·869
February	67·963	78·147
March	68·174	81·111
April	67·017	84·793
May	64·875	84·867
June	65 881	83·994
July	66·887	81·167
August	69·830	83·864
September	69·667	87·831
October	71·406	97·269
November	74·727	100·270
December	78·993	105·226

Neither the remarkable rise which occurred towards the end of the year nor the high average price for the last month is hardly likely to be maintained; but it seems to be agreed that, unless some unforeseen industrial revolution occurs, copper will not fall back to the rates which were prevalent in the nineties. With this promising outlook before us, we ought to be justified in turning our attention again to the deposits in India over which European enterprise failed fifteen years ago.

Aluminium.

The next metal that I should like to direct your attention to is aluminium, which has not so far been smelted in India, although, through the energy of Mr. Alfred Chatterton in Madras, the natives have been taught largely to use aluminium articles instead of brass, and there is now a

[1] From the Engineering and Mining Journal of New York.

considerable industry in the manufacture of articles from imported metal.

Those who have followed the Records of the Geological Survey will know that during the past three years we have established the existence in India of large quantities of highly aluminous laterites, similar in all essential respects to the bauxite used in Europe and America for the manufacture of the metal aluminium Until recently we were compelled to discount the present value of this discovery on account of advice from experts to the effect that the pure aluminic oxide could not be prepared on a large scale in a form suitable for transport to foreign power-works, while, as we were already aware, the raw bauxite would not pay for the heavy export charges. It looked therefore as if we should be compelled to wait until we were in a position to run the heavy risk of incurring the capital charges necessary for the power-works, as well as for the simpler, preliminary stage of extracting the pure oxide. I took up this question when in Europe on leave last year, and found that we had been misinformed: the pure oxide can be calcined and reduced to a form which will permit of transport to any distance in ordinary sacks, and large quantities of such material are now being made from bauxite in Europe for transport to America. In consequence of the surprising nature of our discovery, additional samples have been examined by chemists at home to check the accuracy of our results, which are now established beyond dispute. At the same time, tests on a large scale in European works have given results for the Indian bauxite as favourable as for the best French material.

Having now demonstrated the existence of large deposits of bauxite in India, suitable for the manufacture of pure alumina, the Geological Survey proposes to give way to private enterprise; and if the prospects are not verified in actual

practice, it will not probably be due to any fault in the raw material. The only non-indigenous chemical used in the preparation of the pure oxide from bauxite is caustic soda, and as this is renewed in the process of separating the aluminic hydrate from the solution, there will be no more lost than that due to the ordinary waste.

I have directed your special attention to the question of manufacturing the pure, calcined oxide from Indian bauxite, as its present market value is many times greater than the cost of its transport to European and American ports, while its manufacture is a simple process, involving a small fraction of the capital required for the erection of the power works necessary for reducing the oxide to metal. There must naturally be a certain amount of shyness in risking capital under conditions that necessarily involve many uncertain factors; and, as some of these will be appraised shortly when the electrical works now in contemplation are erected in India, it is possible that aluminium-manufacture may follow soon after the commercial preparation of the oxide; but I would advise no one to court failure at present by combining both risks at once.

That the manufacture of the metal aluminium is remunerative at existing rates is shown by the way in which the five large companies are enlarging their works. The German Company paid a dividend in 1905 of 18 per cent., and, in raising its capital from 16 to 26 million francs, found a banker's syndicate ready to take the new shares at two-and-a-half times their par value. Perhaps more convincing testimony is the fact that the American Company will not publish figures at all, and can extend its works without appealing to the public for funds. It has also absorbed the General Bauxite Company in order to have complete control of the chief sources of raw material in America, and thus be

prepared to hold the lead against all comers when its aluminium patents expire.

With regard to the size of the market likely to be disturbed by new producers, the total production of aluminium can only be approximately estimated, as the largest producer in the world, and the only one in America, refuses to supply any statistics regarding its operations. The following figures, from an article by E. K. Judd in the *Mineral Industry*,[1] represent approximately the world's production for 1905 :—

Pittsburgh Reduction Company ...	about	6,500 tons
Al. Industrie Aktiengesellschaft ...	...	3,675 ,,
British Aluminium Company ...	...	2,250 ,,
Société electrometallurgique française	...	2,325 ,,
Société des produits chimiques d'Alais	...	2,100 ,,
TOTAL	...	16,850 tons

Iron.

Another mineral that promises to be of interest to India in the near future is iron-ore, with which India, according to the popular estimation, is supposed to be richly endowed. In ancient times the people of India seem to have merited their fame for metallurgical skill, and the reputation of the famous wootz steel contributed more than precise knowledge of our mineral resources to the general idea that India is rich in iron-ore of a high-class type.

The iron-smelting industry, it is true, was at one time widespread in India; for there is hardly a district in which slag-heaps are not found; but the native smelter can exist where there are in no sense deposits of a kind that the modern European iron-master would regard as worth his serious consideration. Even on the Kaimur Range, where

[1] E K Judd, *Min. Industry for 1905*, p. 12.

the rocks are barren Vindhyan sandstones, slag-heaps are common; and the only ore that could have been used is that obtained as small lateritic granules formed by the concentration of the rusty cement of the red sandstones. The numerous reports with regard to the occurrence of rich iron-ore deposits in India are thus far from uniform in value, and more often than not describe ores that could not meet the requirements of works constructed on a scale that is now regarded as an economical minimum.

The deposits which have been most frequently noticed in this country are the quartz-hematite and quartz-magnetite schists that occur so commonly as constituents of the group of rocks named *Dharwar* by Mr. Bruce Foote. Lithologically, and in its stratigraphical relationships, this group of rocks corresponds approximately to certain of the so-called Algonkians of the United States, and to some of those classed as Huronian in Canada, where they also include deposits of iron-ore. But most of these occurrences in India have the drawback of being so intimately interbanded with quartz that the only ore obtainable in quantity is highly siliceous and of a low grade. Such occurrences are so common among the Dharwars and their probable equivalents among the more highly metamorphosed schists that newly recorded cases have generally been passed over during recent years as matters of no present interest. But during the past two years, through the persistence mainly of Mr. C. M. Weld and the enterprise of Messrs. Tata & Sons by whom Mr. Weld was engaged, distinct ore-bodies of great size and richness have been established in the Raipur district of the Central Provinces and in the Mayurbhanj State.

In all these occurrences the ore-bodies stand up as small hills above the general peneplain, and thus offer every facility for the cheapest form of quarrying. One of the bodies

in the Raipur district, the smallest judging by superficial appearances, has been tested by the diamond drill to depths of about 120 feet at different points for about 2,000 feet along the ridge, and the cores of solid hematite gave on assay an average of 68·56 per cent. Fe. An analysis by Messrs. Pattinson and Stead of a mixture of representative samples collected by Mr. W. Selkirk in March, 1906, showed that the average ore near the surface contains 68·37 per cent. Fe, with 0·035 phosphorus and 0·021 sulphur. Three one-ton samples from Gurumaishini hill in Mayurbhanj were found to have an average content of 67·92 per cent. iron and only 0·020 per cent. phosphorus.

I have referred to these instances especially because of the vague idea that appears to be prevalent as to the disappointing nature of Indian iron-ore deposits. Most of the recorded occurrences are actually of small importance, and some of those formerly regarded as large deposits would now be considered small. An instance of this kind was examined in 1903 by Mr. E. P. Martin and Prof. H. Louis in the Jubbulpore district, and although their unfavourable report referred to one locality only, there has been a tendency among people with vague ideas of Indian geography to apply this local condemnation to the whole country.

The iron-ore occurrences of India have so far been considered only with the idea of smelting iron in the country; and for the one successful attempt to manufacture iron on a large scale under the exceptionally favourable conditions at Barakar, there has been a long string of dismal failures. The recent discovery of large hematite ore-bodies, in part at least, suitable for acid steel-making, not only affects the proposition of local manufacture, but, with the recent rise in the prices of hematite, opens up the possibility of exporting the ore to the English furnaces.

The only occurrences on which the English iron-master relies at present for non-phosphoric ores are the hematites of the Cumberland-Lancashire area, and the so-called "Rubio" ore of the north of Spain. During 1905 Rubio ore could be obtained at the English ports for about 15 or 16 shillings a ton; but the increased demand towards the end of the year raised the price to about £1, which was maintained through 1906 and gradually forced up until now (Jan. 1907) it is about 24 shillings, and iron-masters see no prospects of any considerable reduction in the near future.

Whilst in the Middlesbrough district last year I had an opportunity of inspecting the assay returns of the ores arriving from the north of Spain, with the intention of comparing their market value with that of the newly discovered hematite-deposits in India. The average assay results of 18 cargoes were as follows :—

Iron in the ore as received ...	...	48·97 per cent.
Moisture	..	9·20 ..
Silica	..	8·90 ..
Iron in dried ore	..	53·95 ..

In his Presidential Address to the Iron and Steel Institute in 1901, Mr. W. Whitwell[1] gave the following as the average assay values of the Rubio ores received at Thornaby in 1890 and 1900, to show that in ten years there had been a degeneration in the quality, following the increased demand on the Spanish supplies :—

	1890.	1900.	
Iron in ore as received ...	50·50	47·99	per cent.
Moisture	9·00	9·10	..
Silica	7·10	10·09	..
Iron in dried ore ...	55·50	52·80	..

[1] *Journ. Iron and Steel Inst.*, LIX. 1901, 37.

Taking the average of these, namely, 49·12 per cent. Iron in the ore as received, in conjunction with the figures that I obtained at Middlesbrough, we have an ore with about 49 per cent. of iron to compare with the Raipur and Mayurbhanj hematites containing 65 per cent. and over. Such an ore on the iron basis alone would thus be worth over 26 shillings at English ports when the market rate for Rubio ore is only £1 a ton, while the Indian ore would bring nearly 32 shillings in the present state of the market. It has still to be proved that the Raipur and Mayurbhanj hematites are throughout sufficiently low in phosphorus for the acid-pig maker, but much of it certainly is; and so long as the present high rates prevail it should be possible to place hematites, like those so near the coast as Mayurbhanj, on the English market at a considerable profit. At any rate, it is no longer wise to put aside as commercially impracticable the proposal to export Indian iron-ores, and it is well to keep this point in mind, not perhaps as a possibly continuous industry, but as one that might be taken advantage of when the prices of ore are high. Unfortunately, the deposits that we know could be worked with a profit for the export of ore are more than 40 miles from the railway, and cannot consequently be developed at present; but the subject is worth the attention of those who may come across occurrences more favourably situated.

The market conditions now are not, naturally, those that will prevail when our railway systems become sufficiently developed to tap the outlying ore-deposits. There is no doubt that the increased drain on the non-phosphoric hematites will assist the present tendency in England to follow the practice, already prevalent in America and Germany, of discarding the acid Bessemer converter for the open hearth. But vested interests are strong, and those who think that acid

steel cannot be replaced by the product of the basic open hearth for certain purposes, have good reasons for their belief. For some time yet, consequently, the demand for non-phosphoric hematites will probably continue, while the increasing output of Spain, now over eight million tons a year, is making a serious inroad into the available supplies. Unless, however, the Indian ores reach the market soon, or some other convenient supplies are found to encourage the retention of the Bessemer converter, the tendency to adopt the open hearth, especially since the introduction of such modifications as the Talbot continuous process, will depreciate, to some degree, the claim of non-phosphoric hematites to special prices.

But the wider question of total supplies of iron-ore, phosphoric plus non-phosphoric, is becoming a subject of concern in view of the rapidly growing increase in the production of pig-iron. The pig-iron production of the world rose from 41 to 54 million tons a year between 1901 and 1905, while 1906 has been conspicuous for its greatly increased activity in all the iron-making districts, and from the estimates already made the full returns for the year will probably show a pig-iron production near, if not over, 60 million tons. The question of a possible exhaustion of ore supplies, about which warnings have been given by such authorities like J. S. Jeans,[1] W. Whitwell,[2] R. A. Hadfield,[3] and E. P. Martin,[4] is daily becoming more important, although it is evident that the data regarding many countries are wholly insufficient for precise estimates. The ore stocks in the Lake Superior region are now placed at a higher figure than they were when less developed six years ago, additional work

[1] *Iron and Coal Trades Review*, LX, 1899, 1192—1194.

[2] *Journ., Iron and Steel Inst.*, LIX, 37, 1901.

[3] *Ibid.*, LXVII, 56, 1905.

[4] *Proc., Inst. Mech. Eng.*, 1905, 346.

having opened up more material than exploitation has removed, and the 300 million tons raised in that wonderful area during the past 50 years form less than a third of the quantity that can be regarded safely as "ore in sight." The recent absorption by the United States Steel Corporation of the ore lands in the Mesabi range belonging to the Great Northern Railway Company will, however, cut off other workers from deposits variously estimated to contain from 500 to 1,000 million tons, being possibly 80 per cent. of the total reserves in the Lake Superior region. For the iron masters of Europe the future is not so certain. Attempts are being made by the Swedish Government to restrict the export of ore in view of a possible scarcity in the near future, and thus, even the makers of basic steel must look ahead for new sources of supply. At the rate of pig-iron output for 1906, probably over 22 million tons for Great Britain and Germany alone, there is a heavy drain on the deposits known within short range of the sea-board, and the prospective value of our Indian occurrences consequently increases.

Electric Smelting.

The use of the electric furnace for the manufacture of iron and steel has become a question of public interest again, largely because of the experiments made at Sault Ste. Marie power station for the Canadian Government. Dr. Eugene Haanel the Superintendent of Mines, made a favourable report on the special advantages of the process for the utilization of various ores that would not yield a metal pure enough for steel in the ordinary coke furnaces, and it appears to be generally admitted that for the manu-

[1] *Iron and Steel Mag.*, Vol XI. May 1906, 401. *Electrochemical and Metallurgical Industry*, IV, 1906, 124-126.

facture of special qualities of steel the electric furnace may find a field for profit, especially in areas far from supplies of coke.[1] The question is of some importance to a country like Canada where the coal supplies are limited to the two oceanic coastal tracts, whilst there are large deposits of ore lying idle in the central regions amongst the old rock-systems that so strongly resemble the Dharwars of Peninsular India. The conditions in Canada that render the electric furnace of possible value for iron and steel-making are analogous in kind, if not in degree, to those of some parts of India where the ore is far removed from suitable fuel, and there is thus a distant, but a very distant, possibility of the manufacture being undertaken in parts of the Himalayan region or in South and West India, where water-power can be cheaply harnessed.

Among the many schemes, wild and sober, that have been proposed for the utilisation of electric power in India, it is surprising that no one has suggested the possible manufacture of ferro-chrome from the chromic iron-ore now being exported from Baluchistan through Karachi. There is *primâ facie* a better prospect of using the electric arc successfully for the more highly priced chrome-steels made in comparatively small quantities, than in the smelting of ordinary irons and steels. The Baluchistan ores bring about Rs. 50-55 in the European market, and might be obtained at Bombay for about Rs. 10 less on account of the differences of freight. If the figures given by the Canadian Commission could be accepted as a guide, the cost of the necessary electric power and raw materials on the Bombay side, when the Ghat electric scheme is in operation, shou'd leave a wide margin between the costs and the market prices

[1] *Cf.* F. W. Harbord The Metallurgy of Steel, 1905, Appendix V

of ferro-chrome. There are, however, too many undetermined factors in the problem to permit a full discussion of it at present, and I merely make the suggestion for the inspiration of any enthusiastic advocate of electric power. For such, an introduction to the necessary literature will be found in a paper read by R. S. Hutton before the Manchester section of the Society of Chemical Industry on the 5th May 1905 ;[1] the article by E. K. Judd, "Chromium and Chrome ore," in the *Mineral Industry* for 1905, p. 70, and Dr. Eugene Haanel's Preliminary Report on the experiments made at Sault Ste. Marie."[2]

Manganese.

I have pointed out elsewhere the waste which is going on through the export of manganese-ore for the use of the ferro-manganese smelter of Europe and America,[3] and my colleague Mr. Fermor, who has made a special study of the manganese-mining industry of India, has strengthened my arguments.[4] Besides the unnecessary tax of freight charges on an ore that contains only 50 per cent. of the metal, another large fraction is lost in the slag and as fume from the blast furnace, and obviously it is cheaper to lose this before the metal reaches the higher cost due to transport to Europe; in other words, this inevitable loss in the process of manufacture gives the owner of a blast furnace in India an advantage over the smelter who has to obtain his supplies of raw material from a greater distance. I understand that this question is receiving the attention of our friends at Barakar, and with the present management there we are

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1 *Journ. Soc. Chem. Ind.*, XXIV, 1905, p. 589.

2 *Electrochem. and Met. Industry*, vol. IV, 1906, 265.

3 *Rec. Geol. Surv. Ind.*, XXXII, 1905, p. 62.

4 *Trans. Min. and Geol. Inst. of India*, Vol. I, p. 69.

certain of a practical treatment of the problem. I need say no more, therefore, on this subject beyond wishing Mr. MacFarlane success, and reminding you that what was an important matter when I wrote in 1904, has become a serious one since the exports of Indian manganese-ores have grown sufficiently to place this country about first among the producers of high-grade ore, with a production that will soon cut a serious slice out of our total resources.

Inorganic Chemicals.

Before closing I must call your attention to one more factor of importance in discussing the prospects of reviving the metallurgical industries of India, and that is our increasing demand for the inorganic chemicals that are in part by-products of some metallurgical operations. During the past three years our average bill for imported inorganic chemicals has been £433,000, and most of the articles imported could be manufactured in the country wholly or partially from native mineral products, the chief items being substances like carbonate of soda, alum, sal-ammoniac, sulphuric acid and copperas.

The consumption of these substances would be increased considerably, in some cases many times, if we could reduce their cost by a serious fraction of the amounts paid for their transport from foreign countries. The one among these chemicals most conspicuously burdened by freight charges, and wanted in cheap supplies, is sulphuric acid. On account of the want of sulphuric acid, your coke-ovens are now wasting nitrogenous compounds worth nearly £100,000 a year, and the other possible outlets for it are so numerous in any community that approaches the complexity of modern civilization that a cheap supply of

sulphuric acid would be followed by a consumption many times more than that represented by our import returns as worth now over £47,000 a year.

The grouping together of several small industries in Europe has enabled the manufacturer to turn to full account the smaller amongst his by-products; and by their utilization, favoured with the reduction in freights following improved forms of transport, the European chemist has been able to kill the native Indian industries in parts of the country far removed from the ports. On account almost entirely of the economical recovery of by-products, the price of sulphuric acid in England has been reduced during the last 70 years from over £18 to under £3 a ton. At the same time, the dependent manufacturer of soda-ash has reduced his prices from over £16 to about £5, whilst bleaching powder has dropped from about £19 to £4-10. Since the opening of the Suez Canal, with the reduced cost of transport by improvements in marine engineering, Eastern freights have dropped to about one-fifth of what they were before the canal was opened. In consequence, the European manufacturing chemist is able to place his by-products at a profit in parts of India where the same compounds are formed by the natural processes of a tropical climate requiring only extraction.

In addition to the profits obtained by an economical recovery of by-products, chemical industry has been largely revolutionised recently by the employment of catalytic agents, such as platinum, copper-chloride and ferric-oxide, which behave as brokers in chemical reactions, effecting the transfer and rearrangement of elements to form valuable compounds, doing their work, however, unlike the usual middleman, for no apparent profit.

The catalytic action of certain inorganic compounds is

essentially analogous to that by which low forms of organisms perform chemical work in a tropical climate. Thus the saltpetre formed in the soil of Behar is due to the useful habits of these low organisms, which are able to oxidise the nitrogenous refuse of the villages into nitric acid, and this, with the plentiful supply of potash, due largely to the ash of wood and cow-dung used by the villagers as fuel, forms our familiar nitrate of potash, or saltpetre.

The utilisation of inorganic catalytic agents on a commercial scale, stimulated by the cheap supplies of energy obtainable from water-power, becomes a serious menace to those who have been enjoying the benefits of an army of organisms working for them without artificial stimulus under a tropical climate. Having had for so long the benefits of a civilized Government, India has had a special advantage over other tropical countries; for, besides having a climate suitable for the production of many raw products required by the richer manufacturing countries, the people have been inoculated by the governing power with a taste for the products of European civilization; and the import of foreign goods, by sharing the freight charges, has made the export of the less valuable raw products possible. Those who have been so active in demonstrations against foreign goods, have overlooked this simple law in political economy that requires an unbroken circuit for trade as much as for a galvanic current

It is well, however, for us to recognise, and so be ready to face, the danger of the tropical product being cut out by the European chemist. Our exports of indigo have steadily dropped from a value of £1,348,569 in 1901 to £387,422 in 1906, due entirely to the work of the European chemist, while our rapidly growing imports of continental beet sugar, costing as much as $3\frac{1}{4}$ million

sterling in 1906, show how the application of science can supersede the disadvantages of climate, and permit the sugar producer to compete in a country 4,000 miles away with those who only collect the simple products of Nature.

Nitrogen.

Among all the forms of activity of the manufacturing chemist, the most interesting from a purely scientific point of view, and the most serious to the owners of a tropical country, is his attempt to mine the greatest of all deposits of nitrogen, the atmosphere. The impression one retains as the result of early teaching at school is that nitrogen is one of the most inert, uninteresting and useless of the elements; that its function in the atmosphere is similar to that of a long soda in a whiskey peg. But later on one learnt that nitrogen is not absolutely indifferent to the attractions of chemical affinity; and the recognition of its predilection for forming temporary contracts of a light nature, in other words, its chemically loose habits, has given rise to one of the most romantic chapters in the history of economic chemistry.

If I could but "speak with the tongues of men and of angels," instead of imitating what you recognise, perhaps, as more in unison with "the sounding brass and tinkling cymbal," I should be inclined to turn aside at this point to tell the fairy story of chemical industry, instead of confining my attention to the less attractive problem of the way in which these things are likely to affect our supply of "pudding."

I have singled out nitrogen for special mention because it is on this point that we are likely to feel the effect of chemical developments, both as regards our wants and our ability to supply. The question of reviving the saltpetre

industry is occupying the attention of our agricultural chemists, while the Members of this Institute are concerned more immediately with the possible effect that the impending changes will have on the efforts now being made to recover the nitrogen that is lost during the process of coke-making. As you know from the Records of the Geological Survey, I have taken an interest in the first essay in the direction of stopping this waste, which has been organised through the energy of one of our Vice-Presidents, Mr. T. H. Ward, at Giridih. Mr. Ward's estimates of profit and loss gave a credit balance of £7 10*s*. a ton on an output of 270 tons a year of ammonium sulphate, valued at £11 5*s*. a ton. In the course of a study of this question last year at home I came across an example of a plant which turned out 280 tons of sulphate during the year 1905, thus fairly near the unit on which Mr. Ward based his calculations. I had an opportunity of examining the books of the Company owning this small sulphate plant, and it was found that after making due allowance for every possible charge, the actual profit of the year was £8 11*s*. a ton when the average price for the sulphate produced was £12 a ton. Mr. Ward has thus underestimated the profits by about 10*s*. a ton.

Practically the only competitor of ammonium sulphate at present is the soda nitre obtained in Chili. The output from Chili is, however, limited, not by the action of Nitrate Committee, as has been asserted, but by the limitations of the labour supplies and water. The demand for both ammonium sulphate and nitrate of soda has increased more rapidly than the supply, and prices have consequently shown a tendency to strengthen during the past few years.

The production of the two compounds is now over $2\frac{1}{4}$ million tons a year, about three-fourths of the total being

nitrate of soda, but it will be seen from table 3 that the average annual price of ammonium sulphate during the last ten years has, nevertheless, gradually improved.

TABLE 3:—*Average Annual Price of Ammonium Sulphate* (good grey, 24%, f.o.b. Hull, per ton.) [1]

	£	s.	d.
1896	7	18	0
1897	7	18	5
1898	9	9	7
1899	11	5	10
1900	11	2	0
1901	10	11	4
1902	11	16	3
1903	12	9	2
1904	12	3	8
1905	12	10	9

The steadiness of the market is shown by the fact that, since January 1902, when the monthly average first touched £11, the average prices for all succeeding months have never dropped below this figure, although the usual seasonal variations, dependent partly on the sugar season, have occurred in the price of both ammonium sulphate and nitrate of soda.

Two other compounds, calcium nitrate and calcium cyanamide, are now claiming a place in the market for nitrogen fertilisers. The Norwegian chemists, K. Birkeland and S. Eyde, have apparently placed the manufacture of the nitrate on a commercial basis at Nottoden in Norway, where the works now being developed are expected to turn out 20,000 tons of nitrate when they attain their designed capacity. In Italy the Societa Generale per la Cianamide

[1] From figures supplied by Messrs. Bradbury & Hirsch.

of Rome are preparing to put into practice Professor Frank's process for the manufacture of calcium cyanamide, which will have the additional advantage of possessing a separate value as a basis for the preparation of other useful chemicals, like the various cyanides. But both these substances are still far from being able to compete with ammonium sulphate, and when their manufacture becomes an established industry, the demand for nitrogen fertilisers will almost certainly have grown. While the trials of calcium nitrate have given general satisfaction to the agriculturist, the experiments of von Seelhorst, Müther, von Feilitzen, Bartsch, Sebelien, P. Wagner and others have shown that the cyanamide may retard germination, and is not universally beneficial in the soil.[1]

On the whole, therefore, there appears to be no present cause for fearing a fall in the value of ammonium sulphate: the nitrate of soda deposits of Chili will not be able to maintain the present output for ever; the manufacture of calcium nitrate and cyanamide are hardly yet commercial successes, while the world's demand for nitrogen fertilisers is rapidly increasing. My advice, therefore, to those of you who are coal owners is this: follow Mr. Ward's example, and lay out some of you your great profits for the erection of by-product recovery ovens.

Conclusion.

There has been a greater activity in mineral developments in India during the past two years than at any time before in the history of the country. Our production has increased, and activity in prospecting operations has

[1] J A. Voelcker, Annual Report on the Progress of Agricultural Chemistry of 1906, pp. 260 and 282.

increased even in a larger ratio. The licenses and leases granted in Government lands alone has grown from about 100 in 1903 to about 250 during 1906; and a great, though not proportional, increase in output has followed. There has been similar activity in the Native States, as well as in the applications for leases over those lands in British districts of which the mineral rights have been ceded with the permanent revenue settlement.

But in trade, as in politics, the most serious time for those responsible for directing the course of events, is not in the lean, but in the fat years It is because of this that I have asked you to consider the trend of recent mineral progress in India.

The fact that applied science in Europe has enabled the chemist and the metallurgist to beat the Indian producer in a country so far from the place of production does not necessarily show that the special products of the tropics are doomed to give way to the artificial substances of Europe. The science that has overcome the disadvantages of climate in Europe is free to the world, and can be utilized also to turn our natural advantages to account in India.

As I have warned you this morning, in metallurgical industries one mineral requires a certain number of others; but our resources have not been so planned during creation that we find the minerals in the relative quantities necessary for metallurgical operations without waste or excess to sell. I was taught to believe in my well-protected youth that the proximity of the nettle and the dock-leaf was but a part of the design that never produced a poison without an antidote near at hand. That may be true in the vegetable world, and devotees of herbs may duly deserve this wise forethought. But those whose business it is to deal with problems earthy have not been treated with the same

consideration, at least not in India. Our ores, fuels and fluxes seemed to have been charged with the same kind of electricity at the time of creation, and so have managed to get as far away from one another as is possible in a small planet. To remedy this defect we have been driven to develop our means of transport, and it is only now becoming possible to realize Ezechiel's dream in its metallurgical interpretation.

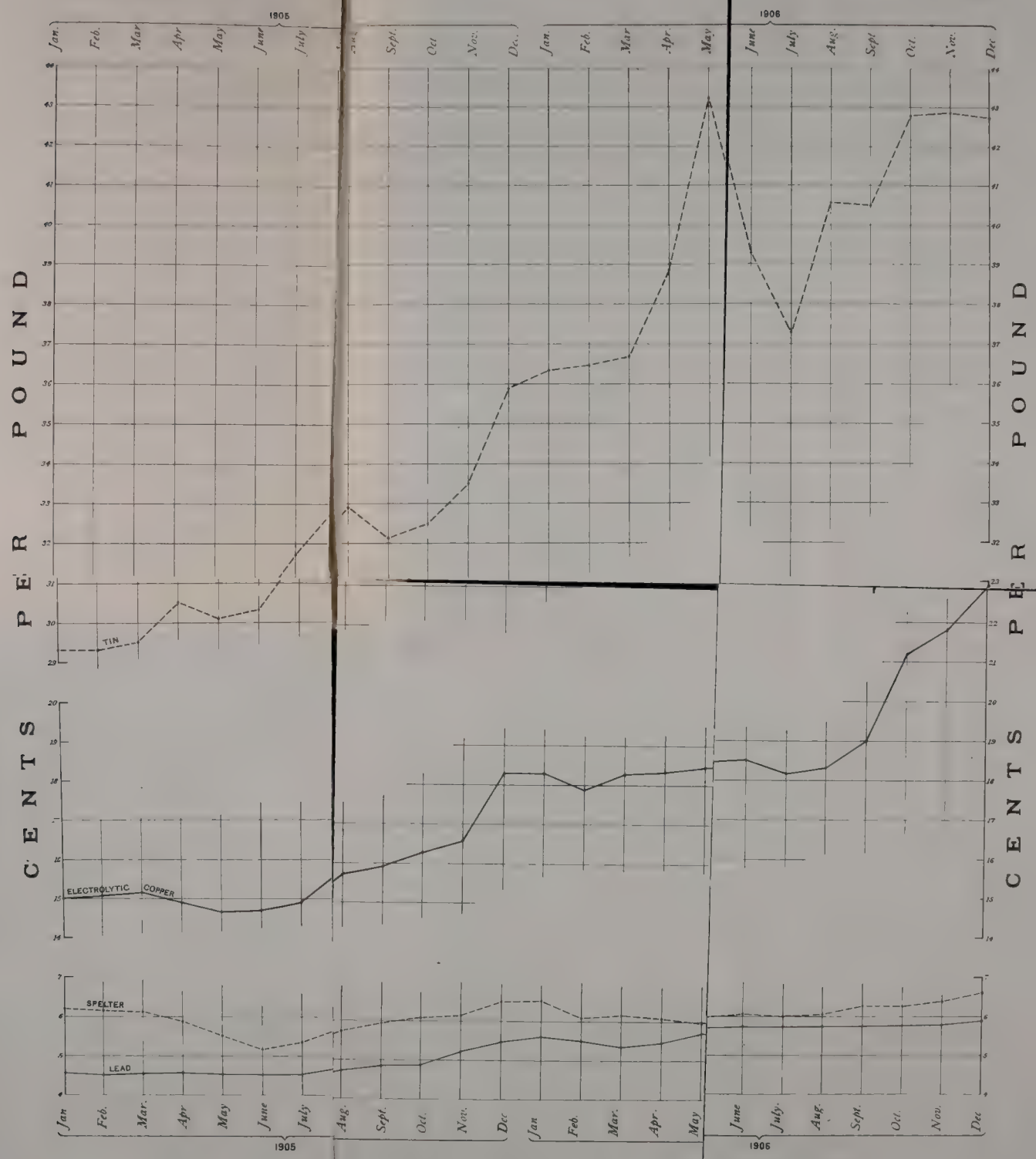
When, ultimately, we are in a position in India to bring the raw materials together, shall we find that we have already exported the principal part of some bone necessary to complete the skeleton? We are sending out manganese-ore at the rate of half-a-million tons a year, and are thus, not only depriving the country of one of the natural products necessary for steel-making, but are receiving in return only a fraction of its market value. Our apparent stocks are still large, and it is better to turn the surplus to profitable account, even if not to the full extent possible, than to allow the mineral to lie idle in the ground. But the simple export of a raw product that cannot be reproduced, and yet is essential to the industrial development of the country, is not a form of trade that can be regarded with unalloyed satisfaction: we are paying dividends out of capital.

It is this question that ought to concern the mind of everyone who has been provided with a trumpet and set in the watchman's tower.

EXPLANATION OF PLATE I.

The diagrams illustrate in graphic form the average monthly prices for 1905 and 1906 at New York in cents per pound of electrolytic copper, tin, lead and spelter. The actual figures given in the table below are taken from the returns published by the New York Engineering and Mining Journal.

	1905.				1906.			
	Electrolytic Copper.	Tin.	Lead.	Spelter.	Electrolytic Copper	Tin.	Lead.	Spelter.
January	15·008	29·325	4·552	6·190	18 310	36·390	5·600	6·487
February ...	15·008	29·262	4·450	6·139	17·869	36·403	5·464	6·075
March	15·125	29·523	4·470	6·067	18·361	36·662	5·350	6·209
April	14·920	30·525	4·500	5·817	18·375	38·900	5·404	6·078
May	14·627	30·049	4·500	5·434	18·475	43·313	5·685	5·997
June	14·673	30·329	4·500	5·190	18·442	39·260	5·750	6·096
July	14·888	31·760	4·524	5·396	18·190	37·275	5·750	6·006
August .. .	15·664	32 866	4·665	5·706	18·380	40·606	5·750	6·027
September	15·965	32 095	4·850	5·887	19·033	40 516	5·750	6·216
October	16·279	32·481	4·850	6·087	21·203	42·852	5·750	6·222
November	16·599	33·443	5·200	6·145	21·833	42·906	5·750	6·375
December	18·328	35·835	5·422	6·522	22·885	42·750	5 900	6·593
Average for year ...	*15·590*	*31·458*	*4·707*	*5·882*	19·278	39·819	5·657	6·198



MONTHLY AVERAGE PRICES OF METALS AT NEW YORK, DURING 1905 & 1906.

A vote of thanks to the President for his address was moved by Mr. Apcar and seconded by Mr. T. H. Ward. It was then moved that the thanks of the Institute be conveyed to the Asiatic Society for the use of their rooms.

Papers read at the previous meeting were then discussed, commencing with that by Mr. L. L. Fermor on "Manganese in India," followed by two papers by Mr. T. H. Ward on the "Internal Examination of Wire Ropes" and on a "Rapid Cage-changing Appliance."

The author demonstrated the practical operation of rope-testing with a rope brought from one of his collieries, and a vigorous discussion ensued. A report of these discussions is printed in the previous volume of the "Transactions" and is therefore not repeated here.

VISITS.

The meeting was then adjourned. A number of members went to the Indian Museum where Dr. Annandale and Mr. L. L. Fermor acted as cicerones. Others went to the Mint and were received by Col. G. M. Porter and Major F. C. Hughes who showed the methods of casting, rolling and stamping in the production of silver and copper coinage.

THE ANNUAL DINNER.

In the evening the Annnal Dinner of the Institute was held at the Volunteer Headquarters. H. E. The Viceroy, the Hon. Mr. J. F. Finlay and many others, representatives of the mineral and railway industries of Bengal, were present as guests.

After the usual loyal toasts had been duly honoured the President proposed the health of His Excellency. He said:—

The proposal of the health of the King's representative will be readily received by you, not only because of the feelings of loyalty

which have just been so freely expressed, but also because of the personal popularity of His Excellency the Viceroy, who has shown his interest in the work of this Institute by graciously consenting to attend the first celebration of our birthday.

It is exactly 100 years since the arrival in India of the first Governor-General who took an interest in our coalfields and thus gave the first official help to the industry which has been the basis on which so many others have been built. I take it as a happy omen that that Governor-General was also a Lord Minto, the distinguished ancestor of our present Viceroy. We thus owe a double debt to the family for the nursing of an industry which has become the largest coal industry in any British dependency, and the christening of an Institute that is to become—well whatever you may make it—under the Minto lucky star.

The remarkable prosperity that follow His Excellency's administration of Canada seems to have followed him to India, for the past year has been from our point of view a record in the country's history, a record in the production of minerals previously well known, and remarkable also for the discovery of a new gem, which has been named the Mining and Geological Institute of India! We have thus many reasons for wishing His Excellency a successful administration and a long life. I ask you, Gentlemen, to join with me in drinking to the health of the Viceroy.

The President read a letter from His Honor the Lieutenant-Governor expressing regret at his inability to attend owing to indisposition.

In reply Lord Minto said:—

Mr. President and Gentlemen,—I am indeed very glad to be here to-night in the early days of your Institute, and on the first occasion I believe on which its members have gathered together round the festive board to celebrate its birthday. I hope that this evening's banquet will be the precursor of many others at which you may in future celebrate the progress and the success of the Institute, the objects of which you are doing so much to encourage. It is quite new to me to be told that my ancestor, Lord Minto, discovered coal in India, although I am thankful to say that he discovered a certain amount in the Kingdom of Fife—for if it had not been for that, well, I don't know where I should have been.

I am afraid, Mr. President, that I cannot pretend to be a surveying or mining expert in any sense of the word. But as it happens, I have seen something of geological survey and mining projecting in days gone by in Canada, under the tutelage of Sir William Dawson and his distinguished son, Dr. George Dawson, President of the Geological Survey of the Dominion, and my experience taught me that the surveyor and the miner do wisely to walk hand in hand, and that the Geological Survey should really represent an intelligence department furnishing the information upon which the miner bases his plan of campaign.

You are now, I know, endeavouring to unite these two branches of science, and nobody will more anxiously watch the results of your labours than I shall. I can only speak as a layman in the presence of experts, but I have seen the great gold mines of British Columbia and their extensive gold-crushing machinery and stamps. I have been down to the bottomest depth of Vancouver Island after coal, I have followed in the wake of a mad rush after gold to Alaska, wandered up the coast of British Columbia and down the waters of the Yukon to Dawson City, I have lived amongst the miners of the Klondyke, and have many friends still I hope amongst the adventurous spirits of the creeks. I have myself handed a sieve and have watched with delight the wet mud making way for its rich sediment of gold, where little machinery is wanted except the machinery of a good constitution, pluck and a share of luck, with an iron determination not to squander one's winnings at the nearest saloon. But wherever I have been I have realised that the discovery of mineral wealth means not only riches for those who keep what they find, but that it is followed also by development of every sort. It is followed by settlement of fresh populations, by the encouragement of industries, and the growth of prosperity in all directions. The miner brings with him his demand for labour, the population that always follow his discoveries bring with it the necessity for further industries, and wealth is disseminated. You in India have a great field before you—a field that has hitherto not been so very much explored; the miner has needed the science of the geologist to tell him of the treasure that is hidden in the bowels of the earth; it rests with the miner to bring that treasure to light, and to furnish the machinery to place it in the market. The forces which your Institute has united will, I hope, prove invincible. I earnestly hope you will meet with support

not only from people at home, but from the people of India. You are helping to develop not only one great industry but many others which must follow in its footsteps. No one will watch your work more carefully and with greater interest than I shall; and I thank you sincerely for the assistance the skilled knowledge of the members of your Institution is giving to the Government in their endeavours to develop the resources of this country.

Sir Ernest Cable then proposed the "Mineral Industries of India," and pleaded for greater recognition and help from Government, especially as regards railway transport. Mr. L. L. Fermor was then called upon to receive the Government grant of Rs. 500 which had been awarded by the Institute for his paper on "Manganese in India"; it was presented to him by H.E. the Viceroy after the conditions had been explained by the President.

SECOND DAY.

The ordinary general meeting, which had been announced for ten o'clock on the following day, Saturday, January 26th, 1907, attracted over forty members. Three papers were read but owing to lack of time it was thought advisable to postpone all discussion, though an announcement was made that written contributions would be welcomed. The first paper was:—

Sampling of Ores and Bullion

BY

Major F. C. Hughes, Assoc. Inst. M. M.

The science of sampling consists in obtaining a small quantity of material, called the sample, which is exactly similar in composition to a large bulk of the same material. The subject may be dealt with under two headings, according as ores or bullion is involved.

I.—Sampling of Ores.

It may be necessary to take the sample from a lode *in situ*, or from a dump of ore raised from a mine shaft.

To sample a lode *in situ*, the best plan is to take a definite quantity of the material at regular intervals, which will depend on the thickness of the lode. This may be accomplished by cutting out with a chisel, by blasting, or by boring holes at regular intervals and utilizing the material bored out as the sample. The most satisfactory method is to take the sample from the freshly blasted rock.

In sampling a dump of the material raised from the lode, the problem is to obtain a really average sample with as little labour as possible. A great deal will depend on the nature of the ore. A homogeneous ore like iron or manganese can be sampled with less labour than one of an irregular character, such as gold quartz (in which the metal is irregularly distributed), or a lode of quartz or calcite with strings of galena, blende, or copper pyrites.

In the former case, a coarser sample will suffice than in the latter.

The whole of the mineral should be reduced to about the size of road metal. It should be well mixed, but not screened or treated in any way which would tend to separate the coarse stuff from the fine powder. It should then be spread over an even floor to a depth of about 18 inches in a square or rectangular heap. This heap is cut through by trenches at right angles which divide it into a number of small heaps (see Fig. 1). From each of these a certain

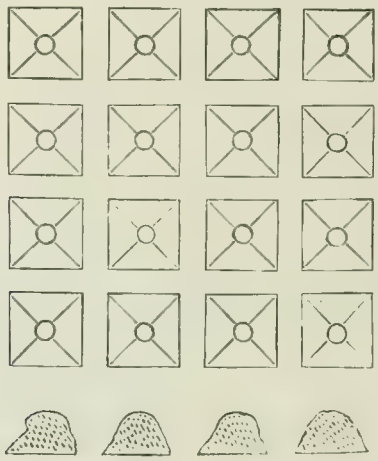


Fig. 1.

quantity of mineral is taken, a little from every part. The quantity selected will depend on the nature of the ore, but will usually be about 5 % of the total bulk. In dealing with a homogeneous ore a smaller quantity of material may be taken than in the case of an ore in which the minerals are unevenly distributed.

The whole quantity thus selected is further reduced by stamping or crushing and is again treated in the manner above described. When considerably reduced in bulk it

may be poured into a conical heap so that the mineral is evenly distributed round a common centre and quartered. This is done by flattening the top of the cone and cutting it into four equal segments by drawing two lines through the centre at right angles to each other. The two opposite quarters are taken and the remaining portion again mixed poured into a heap and quartered until the sample is reduced to a few pounds in weight (see Fig. 1*a*).

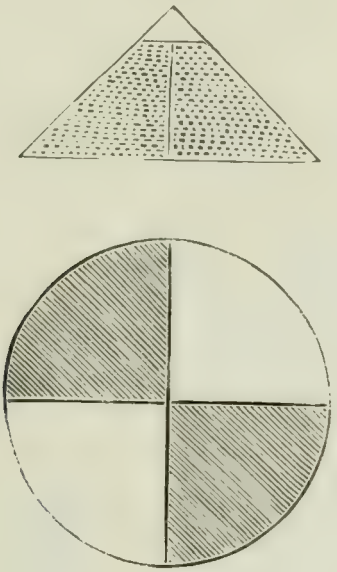


FIG. 1*a*

The sample thus selected will be handed over to the assayer, who will crush it up still finer and again reduce it in bulk by quartering or by some similar methods.

Instead of quartering, an implement called the sampling tin may be used, which makes the operation of reducing the bulk of the ore more expeditious. It consists of a series of tin troughs arranged, side by side, with intervals between them. The ore is poured on to these

with a shovel. That which falls into the tin will naturally be similar in composition to that which falls between. Or an apparatus may be used for quartering the ore, in which two opposite quarters have hinged bottoms, on opening which the ore in those compartments falls through, the remainder being retained.

It is obvious that the finer the ore is crushed the smaller is the quantity required to produce an average sample. This will be understood when it is remembered that the number of particles in a given weight varies inversely with the cube of the diameter of these particles.

Thus if 1,000 particles of an average of 1/10 inch in diameter are taken and crushed into particles having 1/20 inch diameter, their number will be increased to 8,000. If, therefore, it is required to select a small sample from a large mass, this can only be accomplished by reducing to fine powder and thoroughly mixing.

Where rock breakers and crushing rolls or stamps are working, sampling is best performed by intercepting, at regular intervals, the stream of ore as it passes from the rolls or stamps.

This may be done, either by letting the ore fall through a tube vertically on to the apex of a cone, the cone having orifices or slits through which a certain proportion of the ore can pass, which constitutes the sample (see Fig. 2). Or an automatic arrangement can be fitted up by which some of the ore is diverted into a sampling box at regular intervals, as it comes down an inclined plane or shoot. The main object is to have the process as automatic as possible and to eliminate the personal equation in the selection of the sample.

Battery tailings may be sampled similarly by intercepting a portion of the stream of water carrying away the stuff

at regular intervals, and diverting it into a vessel placed there for the purpose.

For fine crushing of ores, so that they may pass through an 80 mesh, the most useful implement is a buck-board. This is a smooth plate of iron about 2-ft. square with a rim on two sides of it. A hammer with a large, smooth

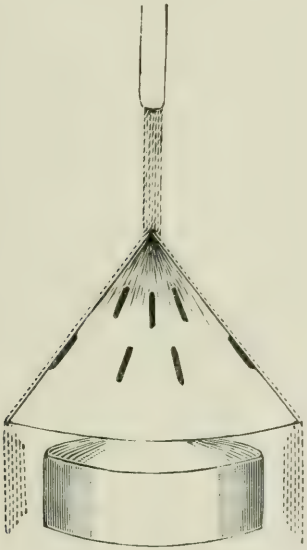


FIG. 2.

curved face and a handle about 30 inches long is used to bring the stuff to a state of fine impalpable powder. The ore should have been first reduced to a coarse sand either by stamping, passing through rolls, or grinding in a mortar with a pestle (see Fig. 3).

The assayer must mix and choose his sample very care-

fully by the same methods as those described above. He may only take a few grammes of material for actual assay, which is supposed to represent the total bulk. It is, there-

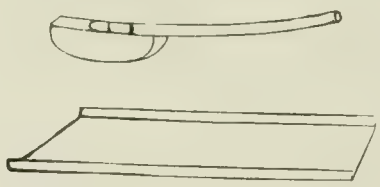


FIG. 3.—Buckboard and hammer.

fore, absolutely necessary that the crushing should be very fine, and the mixing and other manipulations, by which he selects his assay samples, should be carefully and systematically performed.

It is stated above that "a homogeneous ore like iron or manganese can be sampled with less labour than one of an irregular character." As examples, an ordinary hematite and an irregular auriferous quartz may be selected. When hematite is broken into lumps, and two lumps are taken at random and separately assayed, it will probably be found that there is some small difference in the assay report; one lump may contain $\frac{1}{2}$ or 1 % of iron more than the other or slightly more or less silica, and between all the lumps there will be similar slight differences of composition, the greatest variation not running beyond 3 or 4 per cent. from the average. In this case any one lump taken at random will probably give a close approximation to the correct assay value of the whole lot.

Similar treatment of a number of lumps of quartz in which gold is irregularly distributed gives very different results. If these lumps are assayed separately it may be found that one piece carries 50 oz. of gold per ton and another 5 dwt. Obviously either a large number of lumps

must be chosen to represent accurately the value of the whole lot, or the whole lot must be crushed finer before taking out the sample.

By crushing the original lumps into smaller ones and thoroughly mixing, an average sample can be obtained in a smaller weight of material than if an attempt is made to get a fair average of the whole out of the larger lumps. This will be still clearer if an extreme case be taken, say four lumps of quartz each 1 lb. in weight :—

No. 1 assays	50	oz.	gold	per ton.
No. 2	do.	10	do.	do.
No. 3	do.	5	do.	do.
No. 4	do.	1	do.	do

Take any two of these, say Nos. 1 and 2. The average assay will be 30 oz. per ton, or

Nos. 3 and 4 will average	3	oz.	per ton.
Nos. 2 and 3	do	$7\frac{1}{2}$ oz.	do.
Nos. 2 and 4	do.	$5\frac{1}{2}$ oz.	do.
Nos. 1 and 4	do.	$25\frac{1}{2}$ oz.	do.

The correct average of the whole lot is $16\frac{1}{2}$ oz. per ton, and no two of these pieces taken together will even approximately represent the whole four.

If each of these lumps be divided into four lumps of about $\frac{1}{4}$ lb. each, and it is assumed that each of these smaller lumps assays the same as the original piece, there are 16 lumps which may be regarded for the purpose of argument as 16 cards of four suits. With two players the chances are that after proper shuffling each player will receive at least one card of each suit, and it is improbable that either will have all four cards of any one suit dealt him. Without going into mathematical probabilities

experience shows that if the cards have been properly shuffled each player will ordinarily have a certain proportion of each suit in his hand.

The larger the number of cards the better the chance of an equal distribution in this respect.

Now suppose after mixing the 16 lumps we take half the number and obtain :—

2	lumps of	No. 1	assaying	50 oz. =	100 oz.
1	do.	2	do.	10 oz. =	10 oz.
3	do.	3	do.	5 oz. =	15 oz.
2	do.	4	do.	1 oz. =	2 oz.
					8)127

The average assay will be $15\frac{7}{8}$ oz.

The second half will contain :—

2	lumps of	No. 1	assaying	50 oz. =	100 oz.
3	do.	2	do.	10 oz. =	30 oz.
1	do.	3	do.	5 oz. =	5 oz.
2	do.	4	do.	1 oz. =	2 oz.
					8)137

$17\frac{1}{8}$ oz.

These figures are both fairly close approximations to the correct assay of the bulk, yet the distribution of the lumps is one which might easily occur and the chances against say four lumps of No. 1 and four lumps of No. 2 coming together in one heap after mixing, would be many thousands to one.

All intricate mathematical formulæ have been

purposely avoided as it is only desired to illustrate with a clear and simple example the principle on which correct sampling is based.

If the assayer is called upon to sample different quantities of ore, and to give the average assay of the total bulk, care must be taken that the samples shall be proportional to the weights of material they represent. Suppose the average assay of three lots of ore is required.

No. 1 weighs 10 tons and assays 8 % of metal
No. 2 do. 5 do. do. 10 % do.
No. 3 do. 2 do. do. 25 % do.

Then if a 10-lb sample be taken from No. 1, a 5-lb sample must be taken from No. 2, and a 2-lb sample from No. 3. These mixed together will give a correct sample of the whole bulk. Or, if each lot has been sampled and assayed separately, the average assay of the bulk can be obtained by multiplying the percentage value of each lot by its weight and dividing by the total weight of mineral thus—

	Wts.			
No. 1.	10	×	8	= 80.
2.	5	×	10	= 50.
3.	2	×	25	= 50.
				17) 180

10·6 approximately.

The whole bulk will assay 10·6 per cent.

Before leaving this part of the subject a word or two may be said about the treatment of ores and Mint drosses containing metallics. Many ores, especially those of gold and silver, and all Mint sweepings, contain notable quantities

of metallic particles which will not pass through the finer sieves. The best practice is to take a fairly large quantity, say 1 lb. or 2 lbs., or as we usually work on the metric system 500 or 1,000 grammes, pass the whole through a 60 or 80 mesh, placing the metallics which are retained by the sieve on one side. These metallics are then separately assayed and the quantity of precious metal they contain calculated as a percentage of the total sample. The finely crushed and sifted stuff is then mixed, quartered, sampled, and assayed in the usual way, the proportional percentage of metal in the metallics being added to that obtained by assay of the sifted portion.

At Bath's ore yards in Swansea, the writer saw copper ore consisting largely of native copper, which had to be very similarly treated, only on a larger scale. In this case the metallic portion had to be run down and separately assayed, the residue being sampled and assayed in the usual manner.

When it is remembered how important accurate sampling is, and that the reports of the assayer may be valueless without it, it is needless to emphasise the necessity of carrying out this work thoroughly and systematically.

II.—Sampling of Bullion.

There are two methods of sampling bullion:—1st, by cutting or boring pieces from the bars or ingots of metal; 2nd, by melting down the bullion, stirring and dipping out a sample with a scoop. This sample is granulated by pouring into water which is well agitated.

The first method is the one generally used in the Royal Mint for assaying gold and silver, while the second method is more commonly practised in the Indian Mints.

At the Royal Mint in London, the standard gold alloy

is poured into moulds and a piece is cut from the middle of the end of the first and last bar formed. These samples are found to be usually representative of the mass, *viz.*, 1200 oz. In the case of ingots weighing 400 oz., received from the Bank of England for coinage, a single sample is cut from the middle of one of the lower edges of the ingot. If the sample is not representative of the whole ingot, it indicates the presence of other base metals besides copper. Roberts Austin has shown that where pure gold and pure copper are used, ingots of standard gold have a uniform composition, but small quantities of impurities such as antimony, arsenic, bismuth, lead or zinc, cause liquation to take place and make the bars non-homogeneous. In these cases it is better to melt down the ingot under charcoal, stir well and take a dip sample. However, in the case of low standard gold containing much base and volatile metal, such as the bullion obtained by precipitation with zinc filings from cyanide solutions, granulated samples are apt to give too high a result owing to the volatilization of some of the base metal in the melting. In these cases cut samples should also be taken, and, to ensure a fair average, at least four cuts or borings should be made from different parts of the bar.

In the case of silver we find that the alloys generally used for coinage, *viz*; English standard 925 fine, Indian 916·6, and the usual foreign standard 900, are not absolutely homogeneous; and much labour has been spent in ascertaining the best methods of sampling and assaying ingots, straps and coins of these alloys. The method employed in the Indian Mints of sampling all bullion which comes in for coinage, and standard meltings, is as follows:— The metal is melted in large crucibles holding 15,000 to 20,000 tolas, *i.e.*, about 500 lbs. of metal each, under a

layer of charcoal. After lifting from the furnace, and before pouring into the moulds, the contents of the pot are thoroughly stirred with an iron stirrer for several minutes. A ladle with a long handle is then put down to the bottom of the pot and the sample dipped out and poured into water, the surface of which is well agitated with a broom. The quality of the sample and size of granulations largely depend on how this is done, and the men become adepts at pouring in such a way as to produce small and even-sized granules. The tools are shown in Fig. 4. After this the

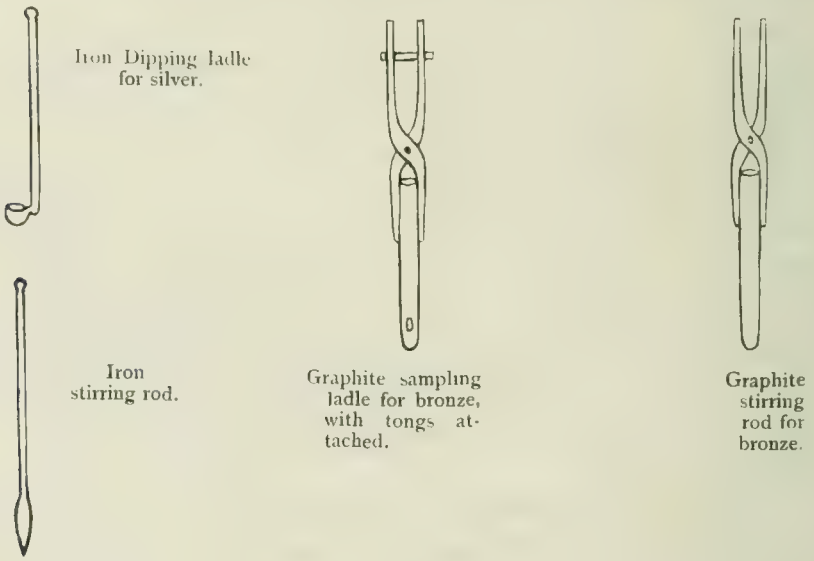
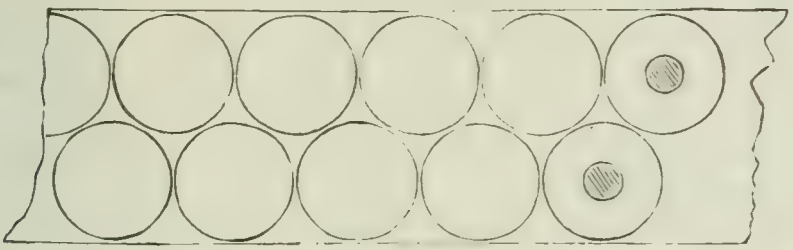

Iron Dipping ladle for silver.
Iron stirring rod.
Graphite sampling ladle for bronze, with tongs attached.
Graphite stirring rod for bronze.

Fig. 4.

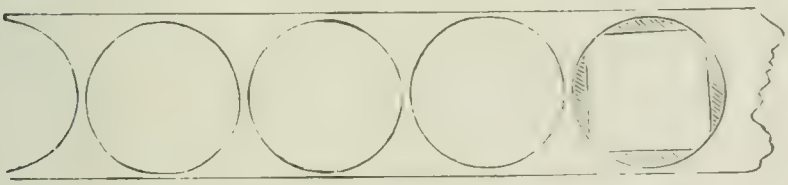
metal is poured into moulds. The granulated sample is thoroughly mixed and one tola of metal (180 grains) is sent to the Assay Office for assay.

This is found to give the average value of the pot with great accuracy, but the ingots cast therefrom, which weigh about 390 tolas or 146 troy oz. each, will vary as much as

2 parts per mille in assays taken from different portions. Likewise coins struck from the laminated straps will vary according to the position in the straps from which they are cut. It has been found after many experiments that the centre of a strap is finer than the edges. This fact has to be borne in mind when assaying coins. Thus the rupee is cut from the strap in two rows (see Fig. 5). A fair sample



Rupee Scissel, or strap, from which rupees have been cut, showing position the coins occupy and how samples are cut



Dollar Scissel, showing position of coins and how samples are cut.

FIG. 5.—[Half natural size.]

can, therefore, be obtained by punching a hole out of the centre of each coin. Large coins like the dollar are cut in one row out of the centre of a strap (see Fig. 5), and, if the assay pieces were all taken by punching out the centres, the results would be too high. To obtain a fair average of the fineness of these coins it is better to take chips from the top, bottom and two sides.

At the Calcutta Mint 10 coins are assayed singly and 20 are melted up and granulated from each lakh struck before being issued to the currency office.

Single coins will vary from 914·6 to 918·6 fine, but the assay of the melted and granulated sample is almost invariably within one or two points per 10,000 of the standard laid down, *viz.*, 916·6, and the average assay of single coins runs slightly lower than that of the melted samples.

The most homogeneous alloy of silver and copper is one containing 718·9 of silver to 281·1 of copper and is called Levol's alloy.

Copper and Bronze.

At Bath's ore yards in Swansea, Chili copper bars are sampled by drilling holes through the bars, at different points, as shown in Fig. 6. In this way each bar is sampled at a different spot, and a good average of the shipment is obtained.

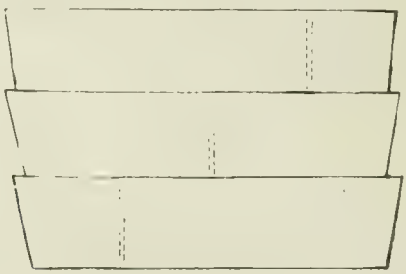


Fig. 6.—Chili bars, showing method of boring samples.

At the Calcutta Mint, bronze is sampled by taking a dip from the crucible similarly to the silver. The results work out very well, though it might be thought that oxidation of the copper would interfere with the accuracy of this method. In comparing the results with assays of the coins themselves, they are found to run very concordantly. Before dipping out the sample, the posts are stirred with a stirring rod made of graphite and not of iron. The sampling ladle is a graphite rod with a hole bored in it (see Fig. 4).

Waste in Bengal Coal-Mining.

BY

Mr. John White.

The question of economical working in the coal mines of Bengal is one which in the majority of cases has hitherto received very little attention. The coal-seams, as a rule, are thick, and lie near the surface, especially in Jherria. The demand for slack coal is practically *nil* at certain seasons, and as huge quantities of it can be stored underground without hampering the work, this is often resorted to as the only way out of the difficulty.

The writer proposes to deal with the subject under seven heads:—

(1) Waste by the miner in the actual hewing of the coal.
(2) Waste of dust coal in the manufacture of coke.
(3) Loss of by-products in the manufacture of coke.
(4) Waste on the pit bank in handling the coal.
(5) Waste in boiler furnaces.
(6) Waste by miners for domestic purposes.
(7) Waste at Kidderpore Docks in the case of export and bunker coal.

This last can scarcely be termed a waste in mining, but as the loss resulting from the primitive methods of handling the coal at Kidderpore Docks swells the total loss to seller and consumer, it is advisable to give the matter the attention it merits

I. *Waste by the miner at the coal face.*—The Indian miner, as a rule, attaches no importance whatever to systematic mining. He hews his tub of coal out of the solid by sheer

force. The fact that the percentage of slack coal resulting from this practice is high, does not trouble him in the least.

At a moderate estimate 25% of the total output is slack coal. In many cases in Jherria the percentage is greater, and in other parts of Bengal where harder coals are being worked, it may be less, but 25% may be taken as a fair average. There is no demand for slack coal at certain seasons, and the demand for coke at all times is limited. The result is that the slack is stocked underground and on the surface, where it deteriorates, and in a short time is useless as a fuel. The total output of coal from Bengal in 1904 was 7,058,980 tons, of which 25% or 1,764,745 tons would be slack coal. It is of course impossible for the mine to get coal without producing a certain percentage of slack, but were the coal properly mined, the percentage should not exceed 10% of the total output. The commercial value of slack coal for steam generating purposes is much less than that of lump coal. The writer estimates this difference at Re. 1-4 per ton. The loss therefore to colliery owners in 1904, taking the percentage of slack at 15% greater than it should have been, was Rs. 13,23,559.

The question of what can be done to prevent this wholesale waste is a serious one. The writer fears there is little hope of improvement in the system of mining as practised by the Indian miner in general and the Jherria miner in particular for a long time to come. The floating population of Jherria is a serious hindrance to more up-to-date methods. The majority of miners in Jherria are unable to undercut, and even if they could, would probably refuse to do so. They have no guarantee that the coal which they might undercut would not be worked off during the night by some other miner,—one of the many who flit from one colliery to another. Were the population a settled one

which depended on mining alone for its living, or were it settled on the coalfield either as a mining community or partly agriculturists and partly miners, an improvement in their style of working might be reasonably anticipated. They could be divided into gangs, half of which would work during the day and half at night, occupying the same gallery, which would overcome any difficulty with regard to the pilfering of undercut coal. The miner in time would recognise the advantage to be gained by undercutting, and would practise the system, and while adding to his own income would effect a material saving to his employers.

Long-wall working can be adopted under a great variety of conditions, but those prevailing in Jherria prohibit its adoption. The seams are too thick, the labour supply is not regular and cannot be depended upon, and the seams lie near the surface, the breaking of which would admit water in the rains,—a serious matter in many cases.

Coal-cutting machines have been suggested by some and tried by a few in the other coalfields of Bengal as a means, it is presumed, of reducing the percentage of slack coal, but most firms and Managing Agents naturally fight shy of embarking on a venture which may not prove sufficiently successful to recompense them for the heavy outlay which the installation of coal-cutting machines would involve. The angle at which most of the Jherria seams lie, would be a serious drawback to coal-cutting machines in the case of narrow working. Moving machines about from place to place would be costly and laborious, unless light machines such as the Hardy or Champion types, which being light are easily handled, were used.

Coal-cutting machines are said to have been adopted in one or two of the Bengal Collieries, and it would be interesting to know how the cost compares with that of hand

labour, and how the increase in output is affected. Though, doubtless, efforts will be extended for the purpose of mitigating this evil, it is probable that the old way will obtain for some time to come, and an outlet for slack coal must be looked for in the shape of coke, when metallurgical industries are more fully developed in India. The coke should be of a better quality than is now being manufactured. The demand for coke at the present moment is not sufficiently great to encourage capitalists to sink money in expensive ovens, either with recovery appliances or otherwise.

II. *Waste of dust coal.*—With one or two exceptions all the coke made in Bengal is manufactured in open kilns, and, as can easily be understood, the waste is enormous, the return being not more than 40% of the dust used. The total quantity of coke at present manufactured in Bengal does not exceed 300,000 tons yearly, while on the basis of 40% yield the quantity of dust used in the manufacture of this is 750,000 tons. Many of the Jherria coals if treated in up-to-date ovens will yield 70% of coke. The loss therefore in rupees due to wasteful methods of coke-making is, supposing the surplus quantity were manufactured into coke and sold at Rs. 4 per ton (the present market value), Rs. 9,00,000 less manufacturing charges, which in India in up-to-date ovens would be very low, probably Re. 1/8 per ton of coke, including up-keep, etc., and would amount to Rs. 3,37,500, the nett profit being Rs. 5,62,500. The extra yield of coke would be 225,000 tons yearly from the same quantity of slack coal.

III. *Loss of by-products in the manufacture of coke.*—These figures represent the loss in coke alone, the other losses being in the valuable by-products which are allowed to escape. From the best of the Jherria seams the yield of tar per ton of coal is 60 lbs., and from 750,000 tons, the yield

of tar would be 20,000 tons, @ Rs. 114 per ton (market value in Calcutta), Rs. 22,00,000. Deducting manufacturing charges, which will be well under 2% of this figure, the loss in profit due to non-recovery of tar sustained by coke-makers in 1904, with market rates @ Rs. 114 per ton, was Rs. 21,50,000. The present yearly consumption of tar in India is well under 5,000 tons, being used chiefly for preservative purposes and for its sanitary properties. An overproduction of tar, as in everything else, would mean a rapid fall in prices, which, in its turn, would probably result in an increased demand. Even though prices dropped from Rs. 114 to Rs. 45 per ton, the value of the tar recovered in the manufacture of 750,000 tons of coal into coke would be 20,000 tons × Rs. 45 = Rs. 9,00,000. Even with such a fall in prices it is probable that the demand in India would not equal the supply for a long time to come; but tar exported from India would cut out home exports to ports east of Suez owing to lower freight. Distillation of surplus tar may also be resorted to, the products being pitch, creosote, etc., and failing a market for these, pitch could be used for the manufacture of briquettes. These are used largely on the frontier Railways and are mostly imported from Cardiff.

Sulphate of ammonia, another valuable by-product, fetches at the present day £12 per ton in England, and for this a like demand would doubtless arise in India at a similar price, say, Rs. 180 per ton. Seven hundred and fifty thousand tons of coal, @ 18 lbs. of sulphate per ton of coal (the average yield for Indian coals) would yield 6,000 tons, Rs. 10,00,000 in value.

Regarding manufacturing charges,—that is, labour cost, price of sulphuric acid,—these should not exceed Rs. 60-65 per ton, if sulphuric acid is available in India. The nett

profit therefore from sulphate of ammonia would be Rs. 115 to Rs. 120 per ton, say Rs. 7,00,000. To import sulphuric acid would be out of the question, freight charges being prohibitive.

IV. *Waste on the pit bank in handling the coal.*—In most cases the coal, on reaching the pit bank, is emptied from the coal tub on to the stacking wharf conveniently near the siding. From the wharf it is loaded into baskets, and carried by coolies to the wagon into which it is dropped in no gentle manner. This double handling causes a great deal of breakage and waste, as the drop from the coal tub to the ground is generally considerable, while the drop from the coolie's basket to the bottom of the wagon is great. At least 5% of the coal is broken and crushed into dust by the rough handling. In some of the Jherria Collieries the coal is emptied direct from the coal tub to the wagon by means of stationary shoots, and in some cases mechanical loading plant is used. The irregular supply of Railway rolling stock to collieries prohibits the general adoption of loading plant, as the output cannot be regulated to suit the wagon supply. Coal must be raised in any case to keep the mines employed, and when wagons are not available, is stacked on the surface to be despatched when wagon supplies are plentiful. Apart from the breakage of coal caused by the extra handling, a further loss takes place when coal is lying in stacks waiting for a supply of Railway wagons. If the stacks are high the coal is crushed, especially near the bottom of the stack, while that on the top, being exposed to the atmosphere, deteriorates and crumbles into dust, all of which goes to swell the slack heaps, an eyesore to everyone concerned. Taking the waste from crushing, deterioration, and rough handling at 7% of the output of steam coal in 1904, we face a further loss of

Rs. 4,60,000, assuming the difference in value of steam and slack coal to be Rs. 1-4 per ton. Until the supply of Railway wagons is regular and plentiful, little improvement in handling coal at the pit banks may be expected.

V. *Waste in boiler furnaces.*—The non-demand for slack coal may be put forward as an excuse for the wholesale waste under colliery boilers. Managers must be more relieved than otherwise to see part of unsightly heaps of slack disappearing. In the majority of cases boilers are fired carelessly; pipes are not covered, while condensers as fuel savers are seldom dreamt of. So long as the economical use of fuel is a matter not worth considering, and the engine is able to do its work, the valves are often neglected, and their setting is in many cases faulty. All this means that fuel is being wasted, and, apart from this, larger and heavier engines and boilers than is necessary are being used. It may be interesting here to note that even in the case of many home collieries, the consumption of coal for colliery engines is oftentimes as high as 10 lbs. per hour per I.H.P., while in the case of up-to-date engines with boilers fired economically, steamship engines, mill engines, etc., for example, the consumption is in many cases as low as 2 lbs. of coal per hour per I.H.P. At least 5% of the output from Bengal Collieries goes to fire the boilers. There is no hope of reducing the consumption to anything like that in a mill. Conditions, especially in Jherria Collieries, are vastly different; boilers are in many cases scattered all over the colliery; engines, unlike mill or steamer engines, are not running continuously; but in spite of all these drawbacks there is yet room for improvement. Were the subject receiving attention, it is probable a saving of 50% of the present boiler consumption could be effected. Taking the present consumption at 5% of the total output, in 1904 the

colliery boiler consumption was 352,949 tons. A reduction of 50% would mean (@ Re. 1 per ton) Rs. 1,76,475 saved annually in fuel for boiler consumption on the collieries.

As already stated, the demand for small coal at certain seasons is *nil*, but in the cold season the demand is generally brisk. This demand, if it could be fully utilized, would do a great deal to clear off the stacks of slack which now cumber the surface. The demand is for tile and brick-burning purposes. The whole of the Gangetic valley and delta is a mass of earth suitable for making bricks, but there is only one season, namely the cold season, in which bricks can be made. Unfortunately for the colleries and their stocks, for the brickmakers, and for the wealthy country whose only building material is bricks, the Railway cannot move the coal for want of wagons.

VI. *Coal used by miners for domestic purposes.*—The miner, on quitting work for the day, on no account forgets to bring out with him his supply of fuel for use in his hut. In Jherria especially the conditions lend themselves to this custom, the coal being worked by adits from which the miner walks out to daylight, carrying his coal with him. The writer on several occasions has taken the trouble to weigh the coal carried out for domestic purposes by several of the miners. In the cold season especially it is a common occurrence for a miner and his wife to take away with them $1\frac{1}{2}$ maunds of the best steam coal daily. At this rate of consumption in a colliery employing 1,200 underground workers, the total yearly consumption at 250 days a year is 8,000 to 10,000 tons. In 1904 the number of persons employed in and about mines in Bengal was 75,749. Assuming the above figures to be correct—and they are near the mark—the total consumption of coal in Bengal in 1904 for domestic purposes among the miners was 500,000 tons @ Re. 1-4 per

ton (difference in value between steam and slack), or Rs. 6,25,000.[1]

The Indian miner, like everyone else, must have fuel, but it is well worth considering if the slack coal lying on the surface cannot be utilized in the shape of briquettes for distribution among the miners for domestic purposes The argument may be put forward that the miner is paid nothing for hewing the coal for his own use True, but arrangements might be made whereby the miner, in return for his basket of coal, which he would otherwise carry to the surface, would receive, on quitting work, a cheque or token entitling him to receive fuel on the surface in the shape of briquettes or otherwise. The question is one of no small importance and will have to be considered some day, when the shallow seams will have been exhausted, and deeper shafts have been sunk to win large areas. The length of roads between the shaft bottom and the coal face will then be such as to make it impossible for the miner to carry out his coal. He must have fuel, and the probability is that the balance at the end of the year will be on the wrong side if he is allowed to help himself at will from coal on the surface.

VII. *Export and Bunker Coal.*—We now come to the question of coal loading at Kidderpore Docks, a question which at the present moment is exercising the minds of many. It can scarcely be dealt with under the head of waste in mining, but considering the fact that Kidderpore Docks give outlet to half of the total output, something of the system of dealing with the coal should be known. To

[1] Since this paper was first written the author has gone further into the question of consumption by miners for domestic purposes and finds that in the hot season the quantity used is less than in the winter months. This figure should therefore be reduced to Rs. 4,00,000.

a stranger visiting the Docks for the first time and watching the coal being thrown to the bottom of the ship's hold, it would seem that no purpose is being served by keeping back the slack coal at the collieries. Indeed, it seems absurd to think that the coal is loaded carefully at the collieries, and that at Kidderpore Docks everyone handling the coal seems to be doing his best to reduce the whole of it to slack or dust. The writer has had many opportunities of watching the loading of steamers with coal at the Docks, and estimates that by the time the loading of the steamer is completed, 30% of the cargo is slack coal. While this may not be a loss to colliery owners it is nevertheless a loss to someone, and taking the commercial value of slack at Rs. 1·4 per ton less than lump coal, with breakage at 30%, the loss in 1905 ton consumers was Rs. 13,52,261. These figures represent the loss due to breakage alone, but as the same freight has to be paid on slack coal as is paid on steam coal, it is probable that they do not cover the whole loss to the consumers.

The actual clearance of coal from Calcutta by the Docks in 1905, cargo and bunker, was 3,606,365 tons. The writer understands it has already been proposed and agreed upon to adopt up-to-date methods of dealing with the coal at Kidderpore Docks in the shape of mechanical loading appliances. These appliances, already in use at home and in other countries, can scarcely be adopted successfully at Kidderpore Docks so long as there is such a mixed rolling stock in use dealing with the coal from the collieries to the Docks. Such appliances are tipplers and cranes for lowering wagons into ships' holds, which could not deal successfully with covered wagons.

Collecting these figures under the different heads dealt with, representing loss to colliery owners and others concerned,

the total yearly loss is found to be Rs. 60 lakhs, as detailed below:—

(1) Waste by the Miner in hewing the coal ...	Rs.	13,00,000
(2) Waste of dust in the manufacture of 300,000 tons of coke	,,	5,62,500
(3) Waste of by-products which could be recovered in the manufacture of 300,000 tons of coke with tar @ Rs. 45 per ton clear, and sulphuric acid available in India	,,	16,00,000
(4) Waste in handling the coal on the surface ...	,,	4,72,000
(5) Waste in boiler furnaces	,,	1,76,000
(6) Coal used by Miners for domestic purposes	,,	40,000
(7) Waste at Kidderpore Docks	,,	13,50,000
	Rs.	60,85,500
	Deduct	2,25,000
	Rs.	58,60,500

Excursion and Visit.

Shortly after half past twelve the meeting was adjourned and the members made their way to the new landing-stage at Chandpal Ghat where the steamer "Buckland" had been placed at their disposal by the kindness of the Commissioners for the Port of Calcutta. This vessel is one of those used as a ferry boat when the Howrah Bridge is opened for river traffic.

After a run down the river past the Botanical Gardens and tiffin had been disposed of, the steamer returned so that the members could avail themselves of the kind invitation of Messrs. Burn & Co. to visit their works at Howrah. The Firm was established as far back as 1781, and has continued without interruption up to the present date. The business was converted into a limited liability concern in the year 1895 owing to the increasing demands for their manufactures and the magnitude of the contracts entrusted to them; and the invested capital to-day is close on £500,000 sterling. Practically every branch of engineering comes within the scope of the works, such as steel constructional work, bridges, pontoons, tanks, all kinds of railway work, shipbuilding, wharves and jetties, land and marine engines, colliery work, mill gearing, engineering stores, irrigation, etc. Each department is under European supervision and the works cover 50 acres of ground.

Last year the total outturn of Ironwork of all descriptions, with the exception of shipbuilding, was about 10,500 tons. The average outturn of the Foundry in the way of castings is 214 tons per month. The Stores Department has, on an average, a turnover of between $2\frac{1}{2}$ and 3 lakhs of

rupees per month, irrespective of goods shipped for the use of the Company. The Shipbuilding Department, during last year 1906, launched a total of 26 cargo boats (the carrying capacity varying from 60 to 600 tons) with a gross registered tonnage of 3,304 tons. Nine steam-launches and steamers were built, with lengths varying from 50 ft. to 195 ft., gross tonnage 942 tons and a total I.H.P. of 2,470. On December 31st, 1906, was launched the largest steamer ever built complete by any Engineering Firm on the Hooghly, namely, the "Bassein." She is 195 ft. long, $46\frac{1}{2}$ ft. beam, with a draught of 4 ft. Her engines are of the Diagonal Compd. Condensing type Cylinders, H.P. 22", L.P. 42", Stroke 54", I.H.P. 850; and she attains a speed of $13\frac{1}{2}$ miles per hour or $1\frac{1}{2}$ miles above the contract speed.

General Meeting.

Held at Asansol on Monday, July 1st, 1907.

A general meeting of the Institute was held at 7-30 A.M. on Monday, July 1st, 1907, at Asansol, in the Headquarters of the Chota Nagpur Mounted Rifles. The chair was taken by the Vice-President, Mr. T. H. Ward. About forty members were present. The minutes of the Annual and General Meetings, which were held at Calcutta on January 1907, were read and confirmed.

It was announced that the following members had been elected :—

As Members—Messrs. F. L. Schwenk, F. T. Marley, Chas. A. Prideaux, E. D. Onract, L. Munn, W. R. Criper, R. Calland, L. A. Jacobs, D. Lawrie, J. G. Herriotts, H. R. Holmes, W. F. Smeeth, R. L. Frizoni, M. W. Travers, H. T. Thomson, C. J. E. David, and R. O. Ahlers.

As Associate Members—Messrs. H. A. C. Gearing, Manilal K. Seth, T. B. Kantharia, H. G. Ambler, and P. Mitchell.

As Associates—Messrs. C. M. Carapiet, Ramji Das and Thakur Das.

As Subscribers—Messrs. Tata & Sons, Parry & Co., Kilburn & Co., and Orr, Dignam & Co.

As Honorary Members—Messrs. W. H. Pickering, R. Bruce Foote, T. W. H. Hughes, E. P. Martin, and Lieut.-General Sir R. Strachey.

The Chairman then announced that there were three papers to be discussed, after which there were two papers to be read and discussed.

DISCUSSION ON MR. WHITE'S PAPER ON "WASTE IN BENGAL COAL-MINING."

Mr. T. H. Ward in opening the discussion said that as the author was a mining engineer it was somewhat strange

that he had omitted to include, in his list of the causes of waste, the main cause of waste, from that point of view, namely, the waste caused by the system of work on which the mines in Bengal were laid out. It was in improvement in this direction that the remedy lies entirely with the mining engineer. On the system of work adopted will depend many important considerations, the principal of which are:—

(1) The maximum yield per unit of area.
(2) The production of the greatest quantity of round (large) coal.
(3) The cost per ton.
(4) The minimizing of loss by creep.
(5) The minimizing of loss by fire.

Enormous quantities of coal have already been lost by creep, and a good deal by fire, in the colliery districts of Bengal. The latter cause is destined to be a source of the greatest loss in the future, from the mining engineer's point of view.

The author of the paper was, in his opinion, much too hard on the Indian miner. What the mining engineer should ask himself is: whether he is meeting the Indian miner's idiosyncrasies in the best way, and whether he is utilizing his muscular powers to the best advantage. His idiosyncrasies are marked; but the Indian miner's powers of endurance are not less than those of his European prototype. No one has yet induced him to lie down when he is "holing"; but the work he can do in driving out a main heading will compare most favourably with the progress which can be made in Europe in similar circumstances. Compare him with the carpenter (burhi), who prefers squatting to standing at a bench; but it is possible to train

burhis to stand, as an inspection of the big workshops in the country will show. The last 30 years, which were covered by the speaker's service, have seen a vast advance in the methods pursued by the Indian miner. A great responsibility rests on the mining engineers of to-day in seeing that the improvement is continuous.

Under the head of "Waste of dust in the manufacture of 300,000 tons of coke," the author has greatly exaggerated the loss caused by the system of coking in open kilns, in stating that 1 ton of coke is made from $2\frac{1}{2}$ tons of dust. If carried out with moderate care the yield will be over 60 % in the case of Jheria coals; or $1\frac{1}{2}$ tons from $2\frac{1}{2}$ tons. Much better results than this can be got by the system in vogue.

Under the head, "Waste in handling the coal on the surface," the author appeared to have omitted consideration of the collieries in which, after the steam coal has been separated from the output, the balance is put through a disintegrator and entirely made up into coke. Many thousands of tons are so treated in Jheria. There would be no definite advantage in reducing the proportion of dust in such a case, and the author's estimate of loss should be reduced accordingly.

The figures given by the author of the imports of tar into India were incorrect, both as regards quantity and value, seeing that he had given the yearly consumption in India at well under 5,000 tons. In Calcutta alone official returns, furnished by the Collector of Customs, Calcutta, to the Agent, East Indian Railway in July 1906, showed that the imports in 1905-6 were 84,239 cwts., or say 4,211 tons. The value of the imports into Calcutta for the year 1903-4 was Rs. 3-9 per cwt., 1904-5 Rs. 3-4-6, and for 1905-6 Rs. 3-4-3; or Rs. 71-4, Rs. 65-10 and Rs. 65-5 per ton as against Rs. 114 stated to be the price in the paper.

From reports made by Mr. G. C. Lathbury, under whose supervision the Jeffrey coal-cutting machines were tried in the E.I.R. Collieries in 1905, the speaker was able to make the following statements of cost in response to the enquiries made by the author. The machines were a special size of the chain breast type, weighed 16 cwts., and made a cut 3ft. on by 2ft. in width :—

A. In places 6ft. in height by 5 ft. in width :—

	Annas per ton.	Percentage of round coal.
(1) Cost for labour without side shear ..	Not stated	
(2) Cost for explosives :—		
(*a*) Without side shear ..	,,	(Nil)
(*b*) One side sheared	5.86	80
(*c*) Both sides ,, ...	3.45	90

B. In places 6 ft. in height by 10 ft. in width :—

(3) Cost for labour without side shear ..	7·38	
(4) Cost for explosives :—		
(*a*) Without side shear	8·22	(Nil)
(*b*) One side sheared	5·00	80
(*c*) Both sides ,, ...	5·57	80
(*d*) Sheared in centre	5·51	80

C. To further illustrate the great advantage to be gained by shearing the following experiments were made using the same amount of explosive as in B (4) (*a*), *i.e.*, in a 6 × 10 place :—

(*b*) One side sheared	..	..
(*c*) Both sides sheared	8·22	93°/°
(*d*) Sheared in centre	..	..

D. The total cost in places 6 ft. by 10 ft. in width works out :—

	Annas per ton.	Percentage of round coal.
Cost for labour [Item B (3)] ..	7·38	..
,, ,, explosives [,, B (4) (*a*)] ..	8·22	..
,, ,, per ton	15·60	..

This cost is exclusive of the following very important items:—

Interest on capital outlay.
Depreciation of plant.
Cost for generating the power used.
Repairs to cutting tools.

It would be of interest to add that the usual rate for driving a 6 × 10 gallery, in the mine in question, is 7 annas 6 pies per ton; and between 60 % and 70 % of round coal is got. This, as seen above, compares with a cost of 15·6 annas per ton, and an output of nothing but slack by machinery. The improved proportion of round coal, when shearing was adopted, was obtained at a prohibitive cost for labour. The fixing of the machine, to make the cut next above the bottom cut, and above that again to the roof, was a very difficult job and increased the cost for labour to quite three times the cost for cutting without shearing.

As regards the type of machine used it was pointed out by the speaker in 1899, when he had an opportunity of investigating the question in England, that the standard Jeffrey 35 cwt. machine, undergoing 6 ft. × 3 ft., was obviously unsuitable for opening out the thick seams of India, South Africa and Australia, and was only suitable

for the wide "rooms" which can be adopted in many (but by no means in all) seams in America. It was also pointed out that narrower openings made the question of shearing, or side cutting, of just as much importance as holing; that it was in fact useless to hole by machinery if you could not shear as well. In response to these suggestions the Jeffrey Company put forward the 16 cwt. machine referred to above, and a light shearing machine. These were accepted for experimental purposes, contrary to his advice.

Under the head "Coal used by Miners for domestic purposes," the author proposed a remedy which is undoubtedly impracticable. The idea of briquetting slack coal, and distributing the briquettes to miners, so as to save the steam coal now carried away by them, in order to save Re. 1-4 per ton, the estimated difference in value between steam and slack, leaves out of account the cost of the operation of briquetting. It is quite clear that the author thought it possible to make briquettes for nothing. If this were so, there would certainly be a revolution in one branch of the coal trade.

It might be of some interest to the Institute to give briefly the cost of making briquettes at Giridih, an experiment which was tried some years ago. The capital cost of the plant, which was capable of turning out 500 tons a week, was about Rs. 40,000. The agglomerant used was meal with lime, and the cost worked out as under :—

	Rs.	A.	P.
Meal	0	11	0
Lime	0	2	9
Labour	0	7	0
Engine stores and coal (for steaming) ..	0	4	7
Interest charge	0	2	4
Total ..	1	11	8

The agglomerant used in Europe is pitch. The cost of that process in this country, where pitch is an imported article, would probably be higher than the meal process. Briquetting with pitch is carried out at the Khost Collieries, and it would be of interest to the Institute if Mr. Mort would kindly give the costs. To return to the paper under discussion, it would be seen that the author, instead of making a profit of Re. 1-4 per ton, would be paying some 8 annas for the privilege of using up his slack coal.

Mr. W. H. Pickering said that Mr. Ward had not altogether appreciated some of the points made by the author and could not entirely agree on the question of coking. Mr. Ward had taken the ideal production of coke, but in practice the yield was about 40 or 45 % on the average. A contractor who made coke many years for a firm kept an account of the amount of coal used and coke obtained, and it worked out to 40 %. Personally, he was of opinion that there was a future for coal-cutting machines in India if they were designed to suit the local conditions. Many of the heading machines on the market were too heavy to he manipulated by Indian labour. He thought light-shearing machines might be designed to be used for deepening the galleries where the mining headings had been driven in the top of a thick seam.

Mr. H. G. Graves said that the author, as already remarked by Mr. Ward, had omitted the consideration of the most material point and that was the waste in pillars. According to all accounts there were large amounts left in the mine in the form of pillars for support of the roof. Flushing systems have been adopted in America and Germany for filling the stalls with waste from coal washing

plants, or with blast furnace slag or quarried material from the surface. Afterwards the pillars could be taken out more or less completely. He did not know whether that system could be adopted in India. The materials were flushed down by the aid of water to the workings through pipes, which were sometimes put down with the aid of special bore holes. The filling was allowed to settle in the stalls. When they were filled, the pillars could be taken out, and the new spaces again filled with flushings from the surface. Ultimately the surface was left undisturbed.

Mr. J. Grundy referring to the question of briquetting, thought that Mr. Thomson who was in charge of the Dandot Colliery, or Mr. Mort who was also making briquettes at Quetta, could doubtless give some information as to costs. The flushing system had not been utilised in India, but a system has been tried for filling the workings with material from the surface. That was in the Central Provinces. The filling was thrown down the shaft and pulled into the workings in tubs. To get the material and place it down in the mine costs just about as much as cutting the coal in the mine. If any member of an inventive turn of mind would get out a patent through the office controlled by Mr. Graves, they might see in the future coal-cutting machines for headings driven by an oil engine.[1]

Mr. G. F. Adams had gathered from the author that the real reason why he omitted the important subject of waste left in mining pillars was that he thought it too extensive a subject to be dealt with in his paper.

The Chairman, in closing the discussion, said that, as

[1] Not a new idea.—Ed.

regards the percentage of coke which could be made in open ovens, he was speaking from many years' experience. Figures given by a contractor could not always be relied on as it might be of interest to the contractor to show a smaller yield.

As regards the future of coal-cutting machines in India, Mr. Pickering appeared to have misunderstood him to some extent. He, the Chairman, was of the opinion, as he had always been, that, if a suitably designed machine could be made available, there would be an immense field for its application, not in India only, but in Africa and Australia, where the coal seams greatly resemble those in India.

A vote of thanks to the Author for his paper was then carried unanimously.

Mr. John White replied to the discussion in writing. In answer to Mr. Ward he thought there was nothing strange in his omitting to deal with the question of "Systems of working" in his paper on "Waste in Bengal Coal Mining." The subject was a most extensive one, and in the writer's opinion was well worthy of a paper to itself. The points mentioned by Mr. Ward as being worthy of consideration would furnish ample material for a paper which would be invaluable to the Institute, to colliery owners and to mining engineers in general. He anticipated the reading of such a paper at no distant date.

Very few mining engineers in Jharia would, he feared, agree with Mr. Ward that Jharia coals would yield 60% of coke manufactured in open kilns. His own experience tended to prove that 40% was the average yield. In this he was supported by several mining engineers in

Jharia whose experience also gave 40 to 45 % as a fair average.

With the commerical value of slack coal @ Rs. 1-4 per ton the cost of slack used in making one ton of coke @40 % yield was Rs. 3-2; with the addition of manufacturing charges, the margin of profit with coke @Rs. 4 per ton was low. From these figures it would be seen that it would be more advantageous to colliery owners if the coal could be got rid of as lump coal. With the commercial value of lump coal @ Re. 1-3 per ton greater than slack coal which the writer had taken @ Re. 1-3 per ton, the commercial value of the coal used in making one ton of coke was Rs. 6-4, *i.e.*, if the coal had not been crushed by being stacked on the surface but despatched as lump coal @ Rs. 2-8 per ton.

Admitting his own figures to be incorrect both as regards quantity and value, and assuming Mr. Ward's figures to be correct, *i.e.*, the average value of tar imported during the years 1903 to 1905 @ Rs. 67 per ton, and also assuming that this figure will be maintained, the actual loss due to non-recovery of tar was Rs. 13,40,000 or Rs. 4,40,000 greater than his own estimates. The value per ton of tar was taken at by him @ Rs. 54 to be on the safe side.

The writer is indebted to Mr. Ward for particulars given as to manufacturing cost of briquettes. Mr. Ward was, however, wrong in supposing that this had been overlooked. It did not follow that though the agglomerating agent hitherto used in India was meal and lime, no other substance was available to serve the same purpose. From Mr. Ward's remarks it is evident that his idea of an agglomerant was confined to meal, lime and pitch ; but it would be of interest to the members of the Institute to know that in some parts of China the agglomerant used is ordinary clay and only a small percentage is required. These briquettes

would, of course, not stand the weather, but neither did the Giridih briquettes when the agglomerant used was an expensive item. No briquettes will stand the weather when the agglomerating agent is soluble in water.

The plant required for the manufacture of briquettes is very simple and very cheap, and the manufacturing cost is very low indeed. These briquettes are used as fuel by the natives.

In conclusion the writer held the opinion that coal-cutting machines of the " Hardy " type could be adopted to advantage in native work and was not aware that this type of machine had even been tried in India.

DISCUSSION ON MAJOR F. C. HUGHES' PAPER ON SAMPLING.

Mr. L. L. Fermor said that the author had made some very interesting remarks about the difference between the accuracy that is necessary in sampling ores, such as those of gold and copper, in which the valuable material is very irregularly distributed, and ores, such as those of iron and manganese, in which the composition is moderately constant from piece to piece. It would, therefore, not be out of place to notice the method of sampling manganese-ores that is found to be satisfactory in the Central Provinces. In the first place it must be noticed that the product of any given mine as stacked after cleaning does not vary much from one piece of ore to another. Thus, in a stack of ore from a given part of such a mine as Mansar and averaging, say, 54 % of manganese, there would be very few pieces containing less than 52 % or more than 56 % of manganese ; whilst in the majority of pieces the manganese would probably lie between 53 and 55 %. Before despatch, the ores of the Central Provinces are usually stored on the mines in rectan-

gular stacks varying in height from 1 to 4 or even 5 feet. When the chemist wished to sample a particular stack he chose one or more points on it according to its size. At each of these points a coolie picked out pieces of ore so as to form a hole going vertically downwards to a distance equal to the length of his arm. Hence a stack of greater depth than about $2\frac{1}{2}$ feet did not get sampled right to the bottom. Nevertheless, experience showed that the analyses of samples thus obtained were sufficiently exact to allow lots of ore giving different analyses to be mixed so as to give a cargo of a calculated standard ; such a method could therefore be taken as sufficiently accurate for ores of such uniformity of composition. In taking samples in connection with his own work in the Central Provinces, it was not permissible, of course, to make holes in the ore-stacks of the different mines, and the speaker decided that it would probably be sufficiently accurate to pace over the stacks and pick up pieces of ore at regular intervals, the actual interval depending on the size of the stack. Thus with small stacks he picked up a piece of ore from the front of his toe at every pace and with larger stacks at intervals of two paces. The number of lines of pacing along a stack had of course to depend on its width. If the sample thus obtained did not weigh more than about 100 pounds the whole was taken. If, however, the amount of ore obtained was very large, as in cases where some thousands of tons of ore were stacked (such was the case at several mines in 1904 when prices were low), the sample was reduced on the spot by quartering and coning until it had reached a convenient size for carrying away. That this method was sufficiently accurate is proved by the analyses, which, in the cases of mines of which the quality of the ore is known, are admitted by the mine managers to be represen-

tative of the average ore of the mine at the time the samples were taken. In taking a sample in this way if one finds on the stack a piece of very impure ore (or of some foreign material), such as would obviously be rejected when the ore was loaded into carts or trucks as the case may be, one of course rejects it and picks up another piece.

Though the method described above is one of the most general methods of sampling manganese-ore used in the C. P., yet it is not the one invariably used. Thus at the Balaghat mine the ore is, when quarried, loaded direct into trucks on various lines, which all converge to the head of a gravity incline down which the ore is lowered to a B. N. railway siding. In this case a certain amount of ore is taken out of each truck before sending it down the incline. A sample was taken thus during November 1906 by Mr. Holmes, manager of the mine, the total amount of ore despatched during the month being 6,714 tons. As each mine truck carries one ton of ore it means that not less than 6,714 pieces of ore were taken for this sample, even if only one piece was taken from each truck. The sample was reduced by the ordinary methods of coning and quartering. The final sample thus obtained must have been as near in composition to the average value of the whole of the ore despatched as it is humanly possible to get, and consequently the assay of this ore, made by Mr. R. D. Connell, chemist to the C. P. Prospecting Syndicate, to which this deposit belongs, must be very close to the true value for the ore despatched during this month. The result of the assay, for which I am indebted to Mr. W. H. Clark, was 51·36 % of manganese, 2·80 % of silica, and 0·07 % of phosphorus.

Whilst dealing with this subject the speaker desired to enter a plea on behalf of the chemists. Although the

variation in composition of the ore of a given mine may be over comparatively small limits, yet it is to be remembered that any given piece of ore is not necessarily of uniform composition from one end to the other. If a piece of the homogeneous C. P. ore, say, even as small as 2 cubic inches in volume, that is weighing about 5 ozs., be broken in half, it is not fair to assume that the composition of the two halves is the same, however homogeneous the whole piece of ore may look. Even if it is the most homogeneous-looking piece of psilomelane that can be found, there may easily be a variation of 1 or 2 % between the manganese contents of the two pieces into which it has been broken. Yet he had known of more than one case where a piece of ore much less homogeneous than the piece mentioned above has been broken into two, one piece sent to one analyst, and the other to another analyst. When the sender finds a variation of 1, 2, and perhaps as much as 5 %, between the two assays, he begins to cast doubts on the accuracy of the work of one or other of the analysts. The only method that can, in such a case, be both satisfactory to the owner of the piece of ore, and fair to the analysts, is to powder up the whole of the piece of ore, and bottle duplicate samples of this powder in the usual way.

Professor P. Brühl, while recognising the value of the work of the chemist, felt bound to say that the results shown by analysis depended upon the way sampling was done. A chemist may take time and care to work out his process and to figure the results in decimals, yet his analysis would be worthless unless the sampling had been done in the right way. The paper said nothing about the sampling of coal. That was more interesting to many of the members than the sampling of ore.

Some years ago the Imperial Institute in London published analysis of the coal in Raniganj coal field, which differed considerably from his own previous analyses of different seams that showed very good average of coals. Of course coal can be sampled so that the results of analyses must differ. This was recognised long ago by the German Mining Engineers, who published in 1884 a mode of procedure which was to be adopted in all cases where coal was to be sent for analysis. Under this system from every truck load, delivered at the bottom of the pit, a sample of the coal is taken out with a shovel and placed in a box. The box is closed so that no dust will fall into it. For analysis the bulk sample is reduced to smaller lumps and spread out into a large square on the floor. There it is quartered by two diagonals ; two triangular portions are shovelled out and thrown aside. The remaining two portions are again reduced to a smaller size and the process is continued. The number of repetitions depends upon the homogeneousness of the coal and the finally reduced sample is submitted to analysis. Instead of going to the trouble of dividing the square into smaller squares and taking out alternate squares, Professor Lunge, who had perhaps more experience about general technical analyses than any one else at the present time, prefers to spread out the sample into a square and to remove two narrow strips parallel to the sides of the square and meeting in the centre by means of a spoon or scoop.

If anyone really wants to have an idea of what the average analysis of a sample of coal is, the most important thing is the initial sampling at the bottom or mouth of the pit. From the commercial aspect, the sampling is done between buyer and seller. It did not interest the buyer of a certain amount of coal, to know from what seam it was

or whether it was from top to bottom. The thing that interested a buyer is the quality of what is bought in that lot.

Mr. Grundy was glad that the sampling of coal for analysis had been considered as well as the sampling of ore, but thought that two points had been omitted. One of them had been left out simply because they had been dealing with the matter from a theoretical and not from a practical point of view. The first point was that of commercial interest. If coal was to be properly sampled by persons who have such great interest in the selling of coal as miners and managers usually had, it was almost impossible, even omitting all considerations connected with cheating, to obtain a proper representative sample. In sampling a seam, especially an Indian seam, one wagon load of coal may be from a particular part of that seam, while another wagon may be from quite a different part. The proper way of getting a sample of thick seam depends upon the way the seam is cut. The proper way is from top to bottom when there are several layers, as the top coal may often be different from the bottom coal. Accordingly, the sample must be taken from wagons which are selected so as to represent properly the different layers if the sample is to be representative of the seam itself. If a sample is to be accurate, a person well acquainted with the samples of coal—and a distinterested person—should cut a sample from that seam, otherwise it is very unlikely that a proper sample would be obtained. Much, however, depends on the object of the sample. If it were for commercial purposes, it should be a sample of the coal in the loaded wagons as despatched for sale. If it were a sample of seam, it should be a sample from top to bottom.

Mr. G. F. Adams pointed out that many persons cut down the whole seam from the roof to the floor. In Jherria the sampler would have to strike down a considerable amount of coal. The Bengal seams had many partings which may vary from a quarter of an inch to four or six inches in thickness, and he would like to be informed what was the least thickness of stone which would be left out when so cutting down, the coals above and below such stone being treated as a separate seam.

Mr. Hallowes asked if the author had tried the following sampling apparatus spoken of by Professor Louis who had seen it used in Sweden. The apparatus consists of three wooden troughs, open at the ends, and V shaped in transverse section, the apex of the V containing an angle of 90°. These troughs—which are very convenient for use in the field, since they can be made there when wanted, without any special tools or materials, from six pieces of 10in. broad, 5ft. long, and a few nails—are placed above each other in step-like fashion. The lowest trough is first laid down on a sheet of American cloth, with its apex upwards, and upon this, at a point half way along its edge, is placed another trough, apex downwards, with its major axis inclined to the horizontal at an angle of about 40° Finally, over this second trough a third one is placed in zig-zag fashion, with its longest axis also inclined to the horizontal plane. The material to be sampled is poured into the top trough, from which it fairly passes down into the one immediately beneath. From the second trough, the ore flows over the upturned apex of the lowermost one which rests on the American cloth, becoming in this way divided into two equal quantities. One of half is taken, and the operations repeated until a sample for analysis is

obtained from the original heap of ore in the field. It has been found that this method is as accurate as the slower one of coning and quartering by hand.

The author of the paper had spoken of the method of sampling by means of a metal cone placed beneath a hopper. Some time ago, he (Mr. Hallowes) devised a practical application of this method, which can be easily carried out with the ordinary materials and tools to be found in any laboratory. As a description of the apparatus may be of use to other members of the Institute, its construction may, perhaps, be briefly described. A hollow cone is made from a thin piece of sheet brass, the apex and sides being well soldered up. With a sharp-pointed piece of steel lines are drawn upon the brass surface dividing the cone into four equal portions, and in the centre of two of the marked-out quadrants which are opposite to each other, small rectangular slots are made at a point half way between the apex of the cone and its base, and the upper edges of these are bent slightly inwards. The base of the cone is closed by a circular piece of brass sheet, which being hinged to the side can be opened as a door. In using the apparatus in the laboratory the brass cone is placed in a large porcelain evaporating dish, which in turn rests upon the iron base-plate of a retort stand. For a 'hopper,' a large filter funnel is taken and clamped so that the end of its glass tube is just over the apex of the brass cone. Powdered ore being then poured into the funnel, flows as a thin sheet over the surface of the cone, and two quarters of the whole material which passes downwards fall through the slots into the inner part of the cone, whilst the other half passes into the evaporating dish. When the first operation is complete the brass cone is taken out of the dish and placed in another. The hinged base of

the cone is then opened and the ore shaken out. The latter is then again passed through the glass hopper, and these operations are repeated several times until a small portion of the bulk of the original material is obtained for analysis. Experiments prove that the method is more accurate and speedy than the old way of coning and quartering on American cloth, for with it the division of the ore is more exactly performed, whilst the operations of coning and quartering are accomplished at the same time.

Mr. H. G. Graves said that the author had not gone very deeply into the question of sampling machines. A very large number have been put on the market and found to be defective. The stream of ore or coal, or whatever material it may be that comes into the machine, was never of the same quality along the length of the stream, nor was it regular in composition in its cross section. Accordingly, if an aliquot portion of the stream were taken either at intermittent intervals or continuously, the sample is not necessarily representative. That was the fault of all sampling machines.

Major F. C. Hughes in reply observed that the class of appliances described by Mr. Hallowes, which would automatically supply the stream and divide it into two portions, might be of great value. He had not tried that method, but thought that any method by which the ore could be dropped in a regular stream into a box divided by partitions would be as equally effective as throwing it on to a sheet of paper, or an ordinary piece of waterproof sheeting or other glazed surface, mixing, and then dividing it. These mechanical contrivances had a distinct advantage in saving time and labour. Mr. Graves' observations were perfectly

true; any apparatus for sampling automatically would have to be carefully watched and regulated or adjusted to provide for appearance of non-uniformity in the stream.

The Chairman, in closing the discussion, said that the most interesting point for a mining engineer was the method of sampling a seam of coal. The method he had adopted in Jherria, when surveying the coalfield in 1890, was to cut down a section of the seam from top to bottom with his own hands, endeavouring to keep that section even. He omitted from that section any band that could be picked out in subsequently treating the coal. The picking out had to be done with care, and could not be neglected, but the partings or other material, which were rejected in the sample, must be of such a nature that they could be removed in screening and picking at the surface when the coal was being prepared for sale. He mentioned that a screening plant was started last Saturday at Giridih, and was then screening the whole of the output of one of his mines. In Europe it was a common practice to throw the coal directly on to the jiggers, which separated and sorted it into sizes, each size being thrown on to its picking belt. In India it was idle to think of adopting that process, because the coal was closely adherent on each side of stony bands or slaty material, so that it had to be chipped off. A large amount of coal was lost in this way in the collieries. It was difficult to get people to do that chipping, and much of what was chipped off was slack and dust. In sampling a seam of coal a diagram should always be given to clearly indicate what bands had been excluded in preparing the sample.

A vote of thanks to the author of the paper was then carried and acknowledged.

Blasting Powder and Premature Explosions.

BY

James Grundy.

Explosives, though not used so largely in India as in England, yet find extensive application in Indian collieries where native-made powders are very commonly employed. Frequently they are the cause of accidents, more or less serious, and a general study of their manufacture and use may be found to be of value.

Blasting powders are usually mixtures of saltpetre, carbon and sulphur. The oxygen in the saltpetre is utilised for the combustion of the carbon and sulphur, and when the ingredients are properly proportioned the combustion proceeds with such violence as to produce an explosion. The initiation of the combustion or explosion depends on the temperature. In this connection the following table of ignition temperatures is of interest:—

Substances.	Ignition Point.	
	Degrees Centigrade.	Degrees Fahrenheit.
Gunpowder (about)	250°	482°
Sulphur ..	250°	482° to 560°
Paper ..	470°	876°
Wood (dry) ..	500°	932°
,, (not so dry) ..	520°	968°
Copper (about) ..	1,093°	2,000°
Phosphorus ..	60°	140°
Iron ..	1,500°	2,730°
Glue ..	190°	374°

In powder the sulphur is the ingredient which ignites at the lowest temperature, and it serves to start and propagate the explosion through the mass. Glue and phosphorus, with their lower ignition points, are of interest as both materials are found in matches and caps which are used to fire gunpowder. Occasionally they may be the cause of premature explosions.

Although the igniting point of iron is very high, it is common to see "brasses" or other hard stones struck by an iron or steel implement when portions of the steel fly away as a burning spark. The behaviour of copper in this respect depends a great deal on whether it is in a hard or soft condition. If it is hard it will readily give off sparks when brought forcibly into contact with a hard stone, and, undoubtedly, both copper and brass, and iron stemmers, drills, scrapers, and prickers have caused many premature explosions of gunpowder by giving off sparks hot enough to ignite the explosive. The author well remembers the time, before this fact was recognised, when he was put in charge of the "copper drill" that was provided for drilling out the charge of a misfired shot.

Hard work or rough usage will harden copper and brass very considerably, so that a soft stemmer of these metals will become hard by use. But it is quite easy to soften those metals, the operation being done in precisely the same way as steel is hardened. A copper or brass stemmer that is probably too hard, only requires to be heated and quickly cooled in cold water, when it will be found to be quite soft, less ready to give off sparks, and so will become a safer blasting implement. Of course, the tool must not be heated unnecessarily often or its substance will be injured, nor must any attempt be

made to heat it to a very high temperature or it might become brittle.

English blasting powder, also called gunpowder, usually approximates to the following composition:—

Saltpetre	..	75% by weight.
Charcoal	..	15% ,, ,,
Sulphur	..	10% ,, ,,

Its composition varies greatly according to requirements of strength and cost. Powder made in different countries also varies a good deal according to the ideas and wishes of the country. Then again, common blasting powder is not much like military powders, used for guns and fire-arms generally, either in chemical composition or in physical condition. "Country-made" powder is generally of the lowest quality of all. An excess of nitre promotes complete combustion and causes an increase of heat to be given off on explosion. When the principal object aimed at is to get the best working effects by increasing the volume of gases developed, the proportion of nitre in the powder is diminished and those of sulphur and charcoal increased. The lessened proportion of nitre used tends to lessen the cost of the powder, which is an important consideration in several respects; but very low price is frequently attended by low quality and poor results. It may be almost accepted as an axiom that the heat liberated by any blasting powder is nearly proportional to the weight of the saltpetre which it contains; and heat is the one representative of power, especially so in an explosion where the principal effect is the sudden development of a considerable expansive force that will do an enormous amount of mechanical work, and work depends principally on the amount of heat generated, this being the measure of the potential

energy or power of the explosive. On the other hand, when this matter is considered in close connection with practical work, the diminished proportion of nitre in the powder and the consequent lessened amount of heat, such a powder will develop an explosion is not altogether a disadvantage when required for blasting coal, but may even be a great advantage, because powder containing less than the usual proportion of nitre is a slower explosive that will "rend" the coal, bringing more of it down and in a better condition. Attempts have been made to produce cheaper powder by substituting Chili saltpetre or sodium nitrate for ordinary saltpetre which is potassium nitrate. It has, however, one great drawback that has not yet been fully overcome, of being very deliquescent. It absorbs water so freely that it is difficult to keep it dry enough to explode, especially in the rainy season. Other substances have been tried to replace nitre, but some of them, such as potassium chlorate, are really dangerous and do not require further mention.

Apart from its constitution, the explosiveness, or the rate at which powder burns, depends chiefly on the following properties: (*a*) extent of incorporation; (*b*) the density of the powder; (*c*) its hardness; (*d*) size of the grains or pieces; (*e*) shape of the grains; (*f*) amount of glaze. And explosiveness is, practically, the quality upon which the explosive for any particular purpose chiefly depends.

English blasting powder with its accurate chemical proportions, and its manufacture by elaborate machinery, is made under the best of care and supervision. A thorough study of English powder would lead to a proper understanding of the behaviour of most kinds of blasting powder even though they be made in India.

Country-made Blasting Powder.—Though such a great

proportion of the blasting powder used in Indian coal mines is "country powder," it is made in a very different way to the English powder, and, when made, it is vastly different; yet it is a very valuable explosive substance.

The author had been into a number of so-called country powder manufactories in India, but has never seen anything more in the way of manufacturing machinery and apparatus than is to be found in a respectable native's hut where the family flour is ground on the spot.

The following description of the methods employed for making country powder is taken from the author's Report of the Khewra Salt Mines for 1896, where details are given of visits to powder works. One maker gave the following interesting particulars of his trade. The ingredients and their amounts used consisted of 5 seers of *gandak* (sulphur), 10 seers of *shora* (nitre washed, but unrefined) and 40 seers of *koila* (charcoal). The percentage composition is thus :—

	English Powder.	Country Powder.
Nitre	75·00	72·72
Sulphur	10·00	9·09
Charcoal	15·00	18·18

The sulphur is bought in roll form. The charcoal is made from stalks of cotton (Kupa) plant. The nitre is unrefined and washed, and is got by regular licensed manufacturers who refine it from the unrefined nitrous earth. Unrefined nitre contains common salt and other impurities.

The Sulphur.—This is broken and ground in a hand-mill and then mixed.

The Charcoal.- First pick out the best, use best charcoal only and mix it with nitre. Then break or pound it, and strain it through a fine flour sieve. The nitre causes the mixture to become damp and it is put out in the sun to dry, and then ground.

The Nitre.—It is first washed by putting it into a piece of cloth and

shaking the cloth about in a *ghara* of cold water, and this water is thrown away. It is then sometimes dried and sometimes not. The sulphur and charcoal are mixed with the nitre, and all three are ground together, damped, dried and pounded again, put out to dry, and shaken into grains in a kind of basket. He says he can tell by the quality of the nitre what the quality of the powder will be—it all depends on the nitre.

The powder is sold at the rate of 5¼ seers to the rupee. He says he cannot tell whether they sell the powder of uniform strength, but when they want to make unusually strong powder they add more nitre.

Another powder-maker said he bought the unrefined nitre, and washed it in the works.

Sulphur.—It is pounded in a mortar and ground in a mill.

Charcoal.—It is sorted, weighed, and mixed with nitre; the mixture is pounded in a mortar and put out to dry. It is then ground in a mill and sulphur added, then mixed with enough water to damp it, and again pounded in a mortar. He then rubs it in his hands, and shakes it in a basket, to form the grains. It is again put out to dry. All ingredients are weighed. He tests the nitre by putting some in the fire and noting how it burns. He can tell the strength of the powder by the quality of the nitre, and if the nitre is weak he increases the proportion of sulphur from 5 to 6 seers.

Unrefined nitre is supposed to contain from 12 to 15 per cent. of common salt and other impurities.

Such is country powder, and the method by which it is made. It is wasteful in various ways; there is no check on the quality, strength, or condition of the powder as sold to the workmen. The powder-makers make just what they think fit, and sell it for blasting powder in any condition they please. And, in the author's opinion, many of these statements even now apply to-day to much of the country powder used in the mines. One of the most noticeable features in country powder is the large proportion of cheap charcoal, which causes it to give off a greater quantity of the most poisonous gases than the well-proportioned and the properly mixed English powder

does. Still, it has advantages that are peculiarly its own, for it is readily believable that the small number of accidents caused by its use is largely due to its poor quality as an explosive. In fact some that is made is so poor that it could not very well cause an accident.

The grains of most of the best powders are glazed with graphite, and this is said to retard ignition. Country powder is not glazed.

TESTING BLASTING POWDER.

It is not at all easy to subject gunpowder to a thorough test, but much that is useful may be done by careful observation and tests in actual practice. The following are some of the physical tests that can be readily applied. For good powder, the grains should not be fine as dust, nor yet very large, though a moderately large grain will make a good slow-burning coal-getting powder. They should be hard, regular in appearance, clean and dry, capable of being handled or put on paper without oiling the hands or paper. It is said that a small quantity of really good powder even ought to be exploded on a piece of paper without soiling it. Dampness is likely to separate the ingredients by dissolving a portion of the nitre, and this crystallises again upon the surface of the grains and is an indication of the treatment it has received in this respect. Another useful test is to flash a little on a glass or procelain plate. If the powder has been thoroughly incorporated, it will "flash" or puff off when touched with a hot iron, with but few sparks and leaving only some smoke marks on the plate. A badly mixed powder will give off quantities of sparks, and leave specks of undecomposed nitre and sulphur, forming a dirty residue with unburnt charcoal.

Good powder gives greater space for tamping than poor powder. Compressed or bobbin powder is much used in England.

Fuses for Igniting Charges.—The fuse itself ignites most readily when the end is cut obliquely with a sharp knife. The fuse should not be bent short, nor kinked. Gunpowder burns more slowly as the pressure is decreased, and will not explode in vacuum. On the other hand, the combustion velocity increases greatly with considerable increase of pressure. These different effects are attributed to the greater or less velocity with which the heated gases escape before having had time to heat the adjacent portions of the solid matter. Therefore, as may be expected, fuses burn slower on high mountains, and every diminution of pressure retards the speed of its burning in the same way that it reduces the speed of combustion of gunpowder.

To ignite blasting powder, a portion of it must be raised to a temperature of 315° C., or 599° F. Fulminate of mercury, of which detonators are made, will ignite if heated to 190° C., or 374° F., according to Berthelot.

The following results of exploding gunpowder in a confined space have been determined experimentally:—

1. The products of combustion are about 57 % by weight of *ultimately solid* matter, and 43 % of permanent gases.
2. The permanent gases at 0°C. and 760 mm. barometric pressure, occupy about 280 times the volume of the original powder.
3. The tension of the products of combustion when the powder entirely fills the space in which it is fired is about 6,400 atmospheres, or 42 tons per square inch.

4. The temperature of explosion is about 4,000°F. (2,200°C).
5. The chief gaseous products are carbonic acid, nitrogen, and carbonic oxide.
6. The solid residue is mainly composed of potassium carbonate, sulphide and sulphate.

The total theoretic work of gunpowder when indefinitely expanded is about 486 foot-tons per lb. of powder. But this great amount of work is little as compared with that being capable of being done by coal. The total theoretic work obtainable from 1 lb. of coal is 4,980 foot-tons, or over 10 times that of gunpowder.

BLASTING.

Turning now to the use and abuse of blasting powder in and at mines, knowledge of the great variety of methods of dealing with powder as used in connection with mining operations will contribute much to an understanding of the causes of premature explosions.

Some of the places in which powder is kept, at and near the mines are:—

(*a*) In magazines.
(*b*) In small huts not constructed as magazines but not used residentially.
(*c*) In contractor's and other houses.
(*d*) In a *Koopie* (leather bottle) in the miner's hut.
(*e*) In the mine itself.
(*f*) More or less loosely in various places above or underground.

It is not meant that powder is actually stored in quantity in all these places, but the quantity, like the circum-

stances, varies greatly; as does also the time during which it is kept at one time in such places.

Blasting powder is carried in and into the mine, etc., in a variety of ways:—viz. in cloths, tin cans, wooden boxes, earthenware vessels, leather bottles and even in the pagree. Charging blast holes is effected in many ways. The powder is put up in proper paper or cloth cartridges, or is used in compressed or bobbin form, and thrust into the hole. These methods are correct, but the use of loose powder or of broken packages or cartridges is to be avoided, owing to the danger of dropped powder. This is not always done, however, and various systems are employed. At the Warcha salt mines the powder is first put into packets called *poltis* and pushed into the up holes. At the Khewra salt mines the practice varies for up holes and down holes. For up holes powder is thrown into the hole with the right hand, the left hand being quickly applied to prevent the powder falling back and on to the floor; the handful of powder is pushed to the top of the drill hole by an iron *Kodali* and a piece of cloth; the drill pushes the cloth and the powder in front of it, and the cloth has a string attached to pull it back with. A piece of cloth is also spread on the floor to catch any falling powder. This is repeated until the hole is charged; and dried clay or marl is used for steming the up holes, an iron pricker being kept in the hole while it is tightly stemmed by means of a drill. For charging horizontal holes the charge of powder is put into the hole, and the other part of the stemming process is carried out in much the same way as for up holes.

For charging down holes the powder charge is simply poured into the hole, the pricker put in, and hole tightly stemmed with marl, using the drill as a stemmer. To pre-

vent the pricker hole getting clogged a thin reed is put into it as soon as the pricker is withdrawn, and while the powder-train is being put in, the reed is lifted little by little as the pricker hole is being filled with powder. The pricker hole is completely filled with powder, and some loose powder is put about the top of it.

An old method, in coal mines, was to throw the charge into the hole by means of the tin lid of the bottle in which the powder was kept, and to push it forward by means of the lip of the scraper, or by the stemmer. To help to push forward all the loose powder lying on the bottom of the hole a piece of paper was often used; and when there was no paper available, a piece of cloth was very often torn from the brattice sheeting for the purpose, without much thought of the injury being done to the ventilation. Also, with similar thoughtlessness with reference to the extra trouble required to mend their old working clothes, the miner has often been seen to tear off cloth from a loosened patch of his clothes for the same purpose. Straw is sometimes used. The tin lid usefully served as the means by which the powder charge was measured.

Of the old methods of charging the shot-hole with powder, there was probably none so much used as the method conveying the powder to the back of the hole by means of the shell of the iron scraper, and probably none so convenient. The shell was filled with powder and carefully pushed to the back of the hole, then the scraper was given half a turn to deposit the powder on the bottom of the hole.

The shell was a really useful means of measuring the charge that was to be put in. Paper, cloth, straw, etc., were also used in this method to push up all the loose powder to the back of the hole.

STEMMING.

A large variety of materials have been, and are being, used for stemming, and much ingenuity has been displayed in an endeavour to improve on the systems that have been considered defective under some of the varied conditions of powder-blasting. Some of the materials and methods are for special purposes, such as to make extra sure that the tamping will stand and not allow a blown-out shot. Some, again, may be said to be for very special purposes such as to prevent the shot igniting fire-damp. A blown-out shot is not only dangerous where fire-damp happens to be present, but is dangerous in other ways, and every effort should be made to prevent it happening. The question of stemming and of tamping material is thus an important one.

MATERIALS USED FOR TAMPING.

1. The borings or dusty material made in drilling the hole. This is very bad if it is coal dust. The dust is usually wetted to make it more adherent, and many ignorant miners think that this is sufficient to make the use of the coal dust safe. The use of inflammable material is prohibited by the Indian Mining Rules.

2. Dirt picked up from the floor and sifted through the fingers to clean it from lumps. It is not cleaned from coal and inflammable material, so that the use of this material may be dangerous, and contrary to the Rules.

3. The "holings," or pricking dirt, where the coal is undercut in the "warrant" or stone immediately below the coal. There is just the same reason for objecting to this as there is to the use of drilling dust and floor dust.

4. Dry clay, or marly material taken from the surface. This is probably one of the best tamping materials

that can be used, being about the most effective and safest. This material is sometimes artificially dried and prepared ready for the purpose by the mine owner ; in other places the miners get and prepare it for their own use.

5. The same materials are sometimes made into special forms, such as a simple dry clay plug, a plug with a hole through for the fuse (very similar to a bobbin of powder), and a plug with a slot on the outside for the fuse.

6. Porous tamping saturated with water, such as sponge and water, and moss thoroughly saturated with water.

7. The charge surrounded with a water jacket, and then stemmed in one of the ordinary ways.

8. Water tamping in the form of a water cartridge, or a cylinder filled with water.

9. Blasting plugs of many kinds have been devised. One consisted of a perforated rod or spindle of about the length that would be required for ordinary tamping and having a screw thread at each end ; upon one end is screwed a conical brass nut, a long cylinder of somewhat rigid vulcanised India-rubber is slipped over the rod, and a nut with a broad base is screwed over it on to the extremity of the rod ; by the pressure of this nut upon the end of the india-rubber tube, this tube is compressed longitudinally and thus made to expand laterally, like a patent bottle cork. Repeated trials both with the original and modified forms showed that they were very expensive and not very reliable.

MEANS BY WHICH THE EXPLOSIVE IS FIRED.

1. First and foremost comes the different kinds of fuses—safety fuse, Bickford's safety fuse, tape fuse, single and double tape, etc., and water-proof fuse, as well as

sparkless fuse. A great deal might be said about these various kinds of fuse, their qualities, behaviour, and the care and treatment required. Every user should be made to understand the bad effects of dampness on fuse, and also of allowing it to become parched in the sun, and why bending the fuse at a sharp angle, and breaking it, is so likely to cause a miss-fire and other trouble.

2. Electric methods of firing perhaps take a second place in India though they are second to none as regards safe firing.

3. Methods requiring the use of a pricker, such as :—

(*a*) Filling the pricker hole with powder.

(*b*) Straw filled with powder, the forerunner of the safety fuse.

(*c*) Paper tubes or squibs, used in the same way.

(*d*) Half of a thin split twig, reed, or bamboo, with the centre pith cleaned out and the space filled with powder paste and dried

(*e*) A hollow reed filled with fine powder.

Methods used for lighting fuse, some being adapted to the use of the old-fashioned quick-running fuse.

(*a*) Lighting the fuse directly by means of the flame of a lamp, candle, match, another piece of burning fuse, smouldering rope or rag or piece of wood, or "live coals."

(*b*) By hot wire from a safety lamp. With such lamps as the Davy and its modifications, the wire is pushed through the gauze to reach the lamp flame; but with lamps that have glass in front of the flame but no gauze in a convenient position a small hole for the purpose is drilled through the glass.

(*c*) By setting a small piece of burning candle to burn through the fuse at a few inches from the end of it.

(*d*) By setting a burning piece of candle, wax taper, wax match, etc., to burn down. When first set, the flame is above the fuse end, but when the flame comes down to the fuse level it ignites the powder in the fuse.

(*e*) Bickford's safety ignitor. This is a suitably-shaped tin tube, one end of which will just slide on to the safety fuse, the other end being sealed. It contains a very small glass bottle containing sulphuric acid adjacent to a small inner tube containing potassium chlorate mixture. The makers supply a special pair of nippers for pressing the outer tube to break the small bottle, and when the sulphuric acid comes into contact with the potassium chlorate mixture a small flame shoots forward to the fuse and ignites it.

(*f*) Other modifications of chemical mixtures have been invented, and used somewhat after the same manner as the Bickford's ignitor. The fuse itself is sometimes prepared by oiling the end.

Method when a pricker hole is used.

(*a*) By using a burning piece of oiled cloth as a train.

(*b*) A smouldering piece of rope, wood, touch paper, etc., when a powder train is used.

(*c*) A thin burning stick or reed with cloth wrapped round it that has been prepared with powder, and the whole used as if it was fuse.

(*d*) An old and rare method, that got over one of the greatest dangers when firing in sinking pits, was to put a small clay ring round the top of the shot-hole, put some powder in it in contact with that in the pricker hole, fasten one end of a string in the clay and take the other end to the surface; the shot was fired by sending a red-hot iron ring sliding down the string.

(*e*) In 1904, an accident brought to light a case of igniting shots, in sinking a well, by throwing hot coals on the explosive charge.

PREMATURE EXPLOSIONS.

Handling, and otherwise dealing with powder, where there are open or naked lights, is a frequent cause of accidents. It would be considered incredible recklessness for a miner to pour kerosine oil from a glass bottle into a hot burning lamp within a few feet of a quantity of blasting powder and dynamite that was laid on the ground. A case of this kind happened a short time ago, the oil took fire, and there was an explosion by which several lives were lost.

Miss-fire shots, and unramming are also frequent causes of premature explosions. In some parts of India, where the Mining Rules are not in force, unramming is rather common. It is sometimes done by the ordinary iron and steel-boring implements; but when the workmen wish to take a little more care, they wet the tamping a little with water and use a bamboo as a kind of drill by twirling it round between the hands to loosen the stemming. One great objection to the supposed safety that is gained by using water is the fact that the men stop using the water when it is most needed for fear of wetting and spoiling the charge of powder, and they get injured instead. At some mines it is not denied that the stemming is got out of the hole again by means of a steel drill.

Miners, and even officials, become so careless that they do things of which they are ashamed after an accident has happened, so that it is sometimes difficult to find out the truth. For instance, an official, preliminary to charging a shot-hole with bobbin powder, put his open lamp on a wheel frame about $4\frac{1}{2}$ ft. from the ground and proceeded

to put the fuse end into a bobbin of powder; he allowed the other end of the fuse to dangle about like a rat's tail until it became ignited from his lamp flame, and exploded the powder he was holding in his hands before he knew what was happening.

At one time there seemed to be quite a run of premature explosions that were said to happen as the charge, or the first part of the stemming, was being pushed into the hole by means of a copper or a wood stemmer. An inquiry into a number of such cases was made without very satisfactory results. One or two cases seemed to point to the powder being ignited by the heat generated from suddenly compressing the air in the shot-hole, a portion of clayey tamping acting as an air-tight piston, and the force and movement being caused by the miner striking a powerful blow at the tamping rod with a heavy sledge hammer.

Premature explosions may also possibly be caused by: (1) Contact of the powder with defective dynamite in the local dealer's shop so as to become slightly but dangerously contaminated with nitro-glycerine. (2) Carriage of the bobbins of powder in the pockets, where there was the possibility of safety matches—usually carried by smokers—lending something to the explosive that would be sufficient to ignite it. These lines of inquiry failed to afford a satisfactory explanation.

At that time the author did not know the temperature at which sulphur—one of the ingredients of gunpowder—could be ignited. But he had an idea that sulphur burned with a flame of lower temperature than any other substance. Accordingly experiments were made to find out the temperature of a sulphur flame, the temperature at which a piece of the bobbin powder could be ignited,

and whether in the act of drilling, etc., the shothole would possibly attain a temperature sufficiently great to ignite the sulphur in the powder and by that means the powder itself. And, although the experiments did not result in the premature explosion of the powder being satisfactorily accounted for, they bore fruit of great value. It was surprising to find that when sulphur was burning, the molten sulphur was much hotter than its flame.

As previously stated, the temperature necessary to ignite blasting powder is usually considered to be about 482° F., but, by carefully arranged experiments, it was found that at a temperature of 350° the sulphur in a piece of bobbin powder burned with a feebly visible flame, without exploding the powder. At 360° the sulphur in the powder burned with a plainly visible flame. At 380° the sulphur in the powder burned with a clear flame, yet this was at a temperature of some 100° *below* that which is considered necessary to ignite powder; and it was found that if this temperature was maintained for a minute or so the powder itself became ignited. But, the bobbins of powder are enclosed in paper, and it was discovered that paper would ignite very much more readily than the powder from the sulphur flame, and, also, that the powder itself would become immediately ignited by the flame of burning paper. So that there was ample experimental evidence that, at a temperature more than 100° below that usually accepted as being necessary to ignite gunpowder, the sulphur in the powder begins to burn and may ignite the powder if that temperature is maintained for about a minute more or less. This shows, that with the help of a small piece of paper, blasting powder can be led to readily and certainly ignite by heat at a temperature no higher than 360° F., which is 122° below that which is considered by authorities to be necessary.

APPENDIX.

The following are the notes written at the time the experiments were made.

Thursday, 6th May 1893.

Experiments with sample of blasting powder (bobbin powder 8 to the lb.) from Ladyshore Colliery; and also with sulphur.

1. Heated—A small piece of powder by putting it on an iron shovel and heating the shovel by Fletcher's gas flame. Result—Some fumes given off, and then sulphur in powder inflamed, when iron was only black hot, and the sulphur continued to burn for a considerable time before the powder ignited.

2. Sulphur (flowers of sulphur) put on a *cold* iron shovel, and the sulphur ignited by black hot iron poker. A piece of gunpowder dropped into the sulphur flame. Result—The powder was in the flame a long time (say a minute) before it exploded.

3. A black hot iron poker applied to a piece of powder, the sulphur *in* the powder ignited a little while before the powder exploded. The iron would ignite the sulphur in the powder, and lead to ignition of powder, when it was only just hot enough to char a piece of newspaper when forcibly pressed by the iron, and when it was barely hot enough to burn the finger.

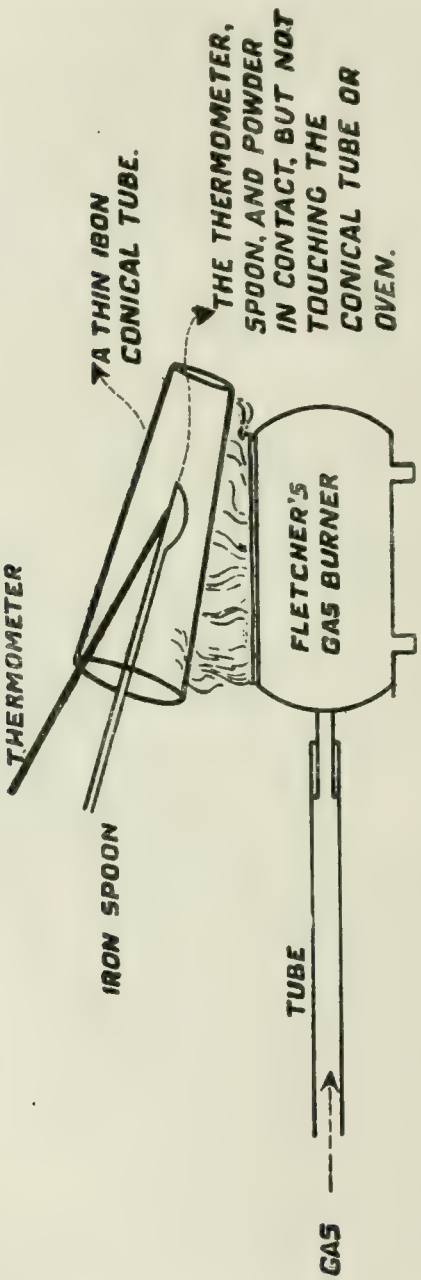
4. A piece of powder was put on a flat-ended poker, when the poker was only just hot enough to char paper. Result—The sulphur flame could be seen, and, in a short time, the powder exploded.

5. Found that a piece of paper would much more readily ignite from a sulphur flame, than powder would ignite from the same flame; in fact the difference was most marked, the paper lighting readily.

6. Black hot poker, just hot enough to char paper, applied to a piece of powder and to a piece of paper in contact with it. Result—Gunpowder ignited much more readily than when there was no paper. It appeared evident that the heat from the poker first ignited the sulphur in the powder, sulphur flame ignited the paper, and paper flame ignited the powder; the poker not being hot enough to ignite either the paper or the powder in a direct way.

Tuesday, 18th July 1893.

7. Failed to ascertain correct temperature of sulphur flame: or to get thermometer to retain heat enough to ignite sulphur or powder.


A THIN IRON CONICAL TUBE.
THE THERMOMETER, SPOON, AND POWDER IN CONTACT, BUT NOT TOUCHING THE CONICAL TUBE OR OVEN.
THERMOMETER
FLETCHER'S GAS BURNER
IRON SPOON
TUBE
GAS

With the arrangement shown in the opposite sketch almost constant results were obtained repeatedly.

The thermometer, and spoon holding the powder, were held by hand: and not allowed to touch the hot tube.

Results—

At 350° F.—Sulphur in powder burned with feebly visible flame.
,, 360° F.—Sulphur in powder burned with plainly visible flame.
,, 380° F.—Sulphur in powder burned with clear flame.

These experiments were repeated a good many times with similar results, starting with the spoon cool: but if the spoon was hot to begin with the registered temperatures at time of ignition were lower, and varied, ignition taking place before the thermometer was heated to actual temperature. The above may, apparently, be taken as the approximate temperatures of experiments 3, 4, 5, and 6.

The discussion on the paper was postponed with the consent of the author.

Fighting a Colliery Fire.

BY

Messrs. W. H. Pickering and R. R. Simpson.

I.—INTRODUCTION.

Perhaps no papers will be more useful to the mining members of this Institute than those which give accounts of difficulties and dangers, and of the practical means which were taken to overcome them. Such a paper gives an opportunity for the united experience and intelligence of the members to be brought to bear upon the problems described, and their criticisms are likely to be of great value in similar emergencies. Failures as well as successes should be recorded, for it is almost as important to know what to avoid as what to do. The writers have, therefore, compiled this short account of a fire at Charanpur Colliery which was exceedingly difficult to control owing to complications perhaps unprecedented in the history of mine fires. In co-operation with the management, the writers were responsible for the plan of campaign by which the fire was eventually overcome, but it is probable that many improvements in both strategy and tactics will be suggested by members in the discussion.

A diary of the principal events during the fire is attached to this paper as an appendix. A general plan of the underground workings is given in Plate IV, and photographic illustrations of the pits before and during the fire are given in Figs. 1 to 6.

II.—DESCRIPTION OF THE COLLIERY.

Charanpur Coal Mine has been worked for many years, being one of the oldest mines in the Raniganj coal-field.

For reasons which need not be detailed here, it was the invariable custom in the early days of mining in Bengal to have numerous shafts and outlets for every mine. At Charanpur there were 15 shafts communicating with the Sibpur seam which is the only seam now worked. Of these, 13 were in what may be described as the old area, that is, to the north of the No. 2 pit dyke. The workings in the seam are divided into four natural districts by three large dykes. The old area comprises three of these districts, the combined area of which is 58 acres. The new developments, covering some 45 acres, are to the south of the No. 2 pit dyke, and are worked from the Apcar pit with No. 18 pit as a downcast shaft. Four connections have been made through the dyke for haulage and ventilation, some of the coal from the new area being raised at No. 2 pit, and No. 4 pit being the fan pit. A glance at the general plan of the workings, Plate IV, will give a better idea of the arrangement of the ventilation, and of the positions of the pits and dykes than the most detailed description.

The Sibpur seam is the only seam now worked. It averages 18 feet thick. The following is a section of the strata passed through in a shaft of a neighbouring colliery :—

Alluvial	.. ..	12′ 0″	
Sandstone	.. ..	116′ 0″	
Shale	.. ..	3′ 0″	
Koithi seam	.. ..	14′ 0″	
Shales and Sandstones	..	56′ 0″	
Sandstone	..	66′ 0″	
Shale	.. ..	3′ 0″	(12′ 0″ at Charanpur)
Sibpur seam	.. ..	18′ 0″	
		288′ 0′	

The shale immediately above the coal is so strong that it seldom breaks down even in the widest galleries, and the sandstones which form the rest of the strata, are very hard and are free from joints and partings.

The common Indian method of working has been adopted; that is, the seam has been cut up into small pillars by wide galleries driven to the full height of the coal. No ribs are left to divide the area worked into panels or districts. In the old workings the drivings are very irregular, and in many cases the pillars are exceedingly weak and small. In the Apcar pit workings, the galleries have been driven at regular distances apart. They average 12 feet wide and the pillars formed have a fairly uniform size of 30 feet wide and 30 feet long.

The mine was ventilated with a Sirocco fan designed to produce 90,000 cubic feet of air per minute. This fan was fixed at No. 4 pit at the north of the No. 2 pit dyke, but Apcar pit, in which there are steam pipes for haulage and pumping, also acted as an upcast.

In the new area the air was directed through the workings by means of doors and air stoppings, but in the old area no attempt was made to course the ventilation, the numerous shafts giving sufficient natural ventilation for the few persons working there.

III.—THE FIRE.

On the 29th March, 1907, a pillar of coal about 100 feet north of No. 4 ventilating pit was found to be on fire. The fire spread so rapidly that in a few hours it was not possible to control or extinguish it by any other means than isolation. The flames did not travel to the fan pit, but spread in the other direction to the rise workings. The fan was stopped, but Nos. 17, 19 and 21 pits became

very active upcasts, and soon began to spout smoke and flame. All the other shafts, with the exception of Apcar pit, eventually were downcasting. The heapstead at No. 17 pit took fire, and the pit frame collapsed. The other two pits were not fitted in any way. The flames belching from Nos. 17 and 21 pits reached a height of over 150 feet. An enormous volume of smoke was issuing with great velocity from No. 19 pit and mingled at a great height with the smoke clouds from the other pits. The writers are indebted to Mr. P. Mitchell for the photographs of the smoking and flaming pits. The camera would only show smoke during the day, the flame photograph was taken at night. The fire could be heard roaring at the bottoms of Nos. 17, 19, 21 and 24 pits, and it was evident that the pillars in a large area were on fire. It was clearly impossible to do more than save Apcar pit and possibly pit No. 22. Dams were commenced in cuttings through the dykes at the points marked A.B.C.D. and H. on the plan. Pits Nos. 4 and 2 were, except for one gallery to the south of pit No. 2, isolated from the fire by stoppings. Through this single opening a large volume of air was rushing to feed the fire. This supply was cut off by the erection of a stopping at the point E. This did not, however, check the fire in the least. The stoppings, built in openings 18 feet high, could not be made tight and would have been useless as a safeguard against an explosion or an air-blast. This was realised, and every effort was made to build the dams. By Sunday, 31st April, the fire had obtained such a hold that a collapse of the workings was imminent, and, as soon as the dams were reasonably sound, it was decided not to risk lives any further.

The men were, therefore, withdrawn from the pits, and the work of checking the fire by stopping the inlets, com-

menced. Nos. 12, 20 and 23 pits were covered with light scaffolds, and earth was thrown down No. 4 and No. 2 pits. The coal at No. 24 pit bottom was on fire and there was great difficulty in getting the coolies to fill it with earth, but eventually this was done. No. 19, as was expected, then became a downcast and was filled up in its turn. In the meantime an underground inspection of the workings from No. 13 incline, which in the early stages of the fire had been inaccessible owing to smoke, showed that the fire was raging along the No. 17 pit dyke. The two cuttings through the dyke (marked F and G on the general plan, Plate IV) were natural places for dams, but it was decided not to risk lives by further underground work. Subsequent events justified this decision. No. 13 incline was, therefore, stopped with masonry and earth, and all the other pits in that area closed, leaving No. 17 and No. 21 open. Roaring flames and volumes of smoke were still issuing from these pits, but No. 21 pit was by far the hotter and for that reason it was expected to upcast. This eventually happened though it downcasted for a few hours, and during that time it was possible to look down it. The pit bottom had the appearance of a steel furnace and the bricks at the pit top and apparently the sandstone lower down were fused. The shaft suddenly again became a furious upcast spouting flame and smoke, and No. 17 downcasted weakly, but as air was being sucked through the dams and scaffolds to feed the fire, No. 17 pit fought hard to upcast. It might get the mastery any moment, and the work of putting on a scaffold was pressed. There were two insets into the shaft at the surface level, and it was determined to fix a scaffold there. The north inset was too hot to allow work there. Long rails were thrust across the shaft

from the south to the north inset, and were covered with corrugated sheets, making a firm scaffold across the centre of the shaft upon which it was possible to venture at intervals and fix cross rails. There was no time to make holes in the side of the shaft for these, but the centre rails were jammed across and driven home with a sledge hammer. The other cross rails were loosely laid on the main rails, and were made firm by long rails passed over them and under rails which had previously been let into the walls of the inset arches for fencing purposes. Thus in about two hours a very firm scaffold was fixed in the shaft. All the holes were stopped, and the work of throwing earth on it was commenced. Whilst this work was in progress, the expected happened. A loud rumbling was heard underground, followed in about three seconds by a violent blast having the effect of an explosion. The light scaffolds were blown off the pit tops, the stopping in No. 13 incline and the dam at H were blown out, and though No. 4 pit was partly filled with ashes, the blast was violent enough to blow off the top of the arch of the fan drift. Nos. 17, 21, 12, and 13 pits spouted smoke and flame. The blast was as violent as an explosion, and many of the spectators were of opinion that there had been an explosion of the gases generated by the fire. There was ample evidence that this was not so, but that a fall in the pit had caused an air blast. There was no perceptible "back-lash," as is always the case in an explosion. Though the fall did not extend to the surface it was possible by deduction to localise it. The fall had clearly taken place along the south side of the dyke on the north of No. 17 pit, partly blocking the two openings, for an underground inspection of the workings, from No. 22 pit, made after Nos. 12, 13, 20, and 23 pits were covered, showed that only about 15,000 cubic feet of air

per minute were passing. If the cutting through the dyke had been fully opened, at least 80,000 cubic feet of air per minute would have passed. The fall had possibly caused the fire to jump the dyke, smoke being found at the point marked Z on the plan. In view of the probability of further falls occurring, it was considered that the risk of rebuilding the dam at H was too great. The temporary dams at A, B, C, and D had fortunately stood the strain, and, as the bricks and cement necessary for strengthening them were on the way, preparations to put in permanent dams from Apcar pit were commenced. Before this work could proceed satisfactorily, it was necessary to reverse the air current at Apcar pit, for putting in the dams had disarranged the ventilation. An examination showed that air was being sucked through the dams, and further falls might blow out the dams, and would certainly force foul gas through them. The stopping at K was knocked out, brattice fixed across the intake airway at M, and the current diverted so as to sweep past the dams. A steam jet was improvised in Apcar pit, and an excellent ventilating current produced. Before the brattice was fixed, a curious phenomenon in ventilation was noticed. The air current of about 30,000 cubic feet per minute had, owing to a breached stopping, a practically straight run to Apcar pit, and it was expected that when the stopping at the point K, close to No. 18 pit, the downcast, was broken, some of the air would flow by the longer route to Apcar pit. But instead of this being the case, the air flowed in the opposite direction as shown on the small plan, Plate III.

Thus a whirlpool of air appeared to be formed, being fed somewhere between Apcar pit and No. 18 pit and joining the main intake a few yards from the bottom of the downcast shaft. Instances o similar phenomena are given

by Mr. J. B. Atkinson in his evidence before the Royal Commission on Mines reported in the "Colliery Guardian" of 15th March 1907. Attention is drawn to a somewhat similar case by Mr. St. J. Champion Jones in a paper entitled "A Gob-fire in a Shropshire Mine," appearing in the Transactions of the Institution of Mining Engineers, Vol. xxxiii, Part 2. In the Charanpur instance, the motive-power producing the whirlpool current may have been the heat caused by the burning of the lamps of the large number of persons (about 100) employed in the neighbourhood of the dams. Pit No. 18 lies to the rise of the dams, and the natural course for this heated air, apart from that sucking through the dams, would be in this direction.

As soon as the ventilation was made satisfactory, the work of strengthening the dams was pushed forward. The dams, A, B, and C were strengthened by a packing of sand and dirt kept in position by brick-retaining walls. When the bricks and cement arrived, permanent dams were commenced. The bricks were Raniganj fire-bricks, about 1,000 being $12'' \times 9'' \times 5'' \times 4\frac{1}{2}''$ and the remaining 20,000 $9'' \times 4\frac{1}{2}'' \times 3.''$ Local advice was obtained as to the best mixture of the local "guting lime," sand and cement to form a hydraulic cement. The unanimous opinion was that the mixture should be one part of lime, one of cement and one of sand. This was used, but unfortunately time proved that it was unsatisfactory. For the last sections of the dams a simple mixture of cement and sand was used. There was no time to dress the hard dyke stone for damming places. As the dams would have to be gas tight, to be able to resist the impact of a possibly very violent air blast, and subsequently to withstand the pressure of a considerable head of water, it was determined to give the dams great weight and substance. It was recognised that

little reliance could be placed upon the work done from the No. 2 pit side, for it was very hastily done with makeshift material. The construction of the dams when finished is shown by the sections on Plate II. The sketches show that the dams are constructed of separate rings of bricks with a vertical grouting of cement between each ring, but in two of the dams one section of "header and stretcher" brick work was put in. This work was done under the supervision of a manager who had had great experience in dam building at home. The work was very well done, and the dams were not materially weakened by this departure from the design. It will be noticed that two 4″ pipes fitted with cocks and a pressure gauge are built into B dam.

Until the dams were gas-tight it would not have been safe to completely bottle up the fire, for a mixture of deadly gases, probably containing CO, would have been forced through the dams on to the workers, and would probably have made work impossible. All the pits except No. 25 as a downcast and No. 17 and No. 21 as upcast were closed. No. 17 pit is 10′ 3″ in diameter, but, as the scaffold in it had stood the strain of the air blast, small holes only being blown round the sides, there would be no difficulty in closing it when the proper time arrived. To prepare for a second scaffold the insets were blocked with iron plates backed with mud and masonry. No. 25 and No. 21 pits were only 6 feet in diameter. Iron plates 7′ 6″ in diameter with holes 2′ 0″ in diameter in the centre covered with hinged lids, were prepared for covering them. The idea being that in the event of air blasts caused by further falls, the plates would act as safety valves, and prevent damage to the permanent scaffolds on the other pits. Violent blasts would lift the plates, and less violent ones the hinged doors. The doors would also be useful for

making observations. The question of safety scaffolds and air-blasts is discussed in section V.

On 11th April the work on the dams was sufficiently advanced to justify closing all the pits. The plate was placed over No. 25 pit, thus stopping the only intake. The cocks on the pipes at dam B were closed. The scaffold at No. 17 pit was quickly made tight with mud, and the plate was then lifted on to the top of No. 21 pit, and the edges plastered with mud. These final operations took less than an hour. An inspection of the dams was made the following morning and no gas detected. There was some pressure behind the dams, for the pipes at B dam "blew" when the cocks were opened, but the fresh air, which had been previously passing through the pipes, had not had time to mix with the foul gases generated by the fire. The cocks were kept open for about a minute, but the air which came through had no effect on a chicken held in it. The plates and scaffolds over No. 17 and No. 21 pits were very hot, and there was a slight pressure of gas against them. It was decided to let the pits rest for a week before allowing work in Apcar pit.

A surface and underground inspection was made on 20th and 21st April when the condition of the dams and scaffolds was found to be most satisfactory. From observations through small holes in the plates over No. 25 and 21 pits, and at the pipes through B dam it was evident that the fire was dying and that condensation was already in progress. Air was drawn inwards in each instance. This also proved that the dams and scaffolds were fairly gas tight.

On 20th April a thermometer, lowered through a hole in the plate covering No. 21 pit, gave a temperature of 212° at a depth of 30 feet from the surface. On 12th May it had fallen to 154°, and on the 3rd June to 138°.

IV.—CAUSE OF THE FIRE.

A knowledge of the cause of the fire would be of great practical value, and much speculative interest has been aroused on this point. Various rumours have been current in the coal-fields. Of these the most persistent have been (*a*) that the fire was due to the heat engendered by the crushing of small pillars of coal; (*b*) that the outbreak was caused by the spontaneous combustion of dust coal left lying in the galleries. The first of these theories is discounted by the fact that the five pillars first found on fire measured 22×12, 30×15, 22×16, 30×18, and 21×20, the cover being about 180 feet in thickness; and that one of the writers soon after the outbreak carefully examined the burning pillars and found no evidence of crushing. As regards the second theory we have the positive statement of the Manager that there was no dust coal lying in the galleries where the fire broke out. During the inspection of the burning area referred to above, the same observer took particular notice of the fact that no dust coal was to be found lying in the galleries either adjacent to or at some distance from the burning pillars. A similar condition of affairs obtains throughout the workings of the mine now accessible, and it appears to have been the practice to remove practically all dust coal from the mine.

The explanation to which the Manager of the mine attaches credence is the accidental ignition of a pile of tramway sleepers said to have been lying at the place of outbreak. When the sirdar brought the first news of the fire, his statement to the Manager's servants was that a stack of sleepers was on fire near No. 4 pit. When questioned subsequently by one of the writers, he denied seeing

anything but smoke, probably through fear of blame. Until a month before the fire broke out the coal from the north-eastern portion of the Apcar pit workings was hauled to No. 17 pit, along a tram line which passed three pillars to the west of pit No. 4. An eastern branch of the line took off at a point three pillars north of pit No. 4, and passed through the gallery where the fire was first discovered. This tram line is said to have been laid on the stone floor with from 6 to 12 inches of coal ballast. It had been pulled up about a month previously, and the sleepers and rails had been stacked at intervals along the road. It appears probable that one of these stacks would be at the point of origin of the fire, but there is no direct proof that this was the case. At about 6 P.M. on the night before the outbreak some twelve persons went to work at a cutting through a trap dyke 450 feet south-east of No. 2 pit. To reach this spot it was necessary for them to descend No. 2 pit, go through a ventilating door three pillars west of No. 2 pit, pass round to the north of No. 4 pit, and travel along the eastern branch of the old tram road. They would thus actually pass the point where the fire broke out. That they were quite ignorant of the fire is proved by the fact that they remained in the mine until rescued by the Manager at about 7 o'clock the following morning. All these persons except one, a sirdar, left the neighbourhood that day, and have not been seen since. The sirdar, on being questioned by one of the writers, maintained that they all carried small oil-lamps, no torches were used and they did not sit down near the point where the fire broke out. It seems reasonable to suppose, however, that on their journey in-bye they by some means caused the stack of sleepers, presumed to be there, to take fire. The colliery surveyor subsequently stated

that on one occasion he had seen coolies sit down there and make a small fire for the purpose of lighting a hookah.

Notwithstanding the foregoing, it may be mentioned that the space between a stack of sleepers and the side of a pillar would, if slack or dust coal had accumulated there, be a likely place for the commencement of spontaneous combustion.

V.—AIR-BLASTS.

Fighting the Charanpur fire was made more difficult by the danger from air blasts. The question of air-blasts deserves very serious consideration in India, for the danger will increase greatly as the areas cut into pillars become larger. If the pillars are to be extensively worked, the problem of the control of the roof will have to be solved. At present there is far too little information on the subject. An admirable paper by Mr. T. Adamson, read before the North of England Institute of Mining Engineers, gives an account of air-blasts at Giridih where the falls are controlled. Instances of serious accidents from air-blasts are given in the Annual Report for 1905 of the Chief Inspector of Mines in India.

Air-blasts are caused by two classes of falls: (1) by those which extend to the surface and (2) by those which do not. In the case of falls to the surface the blast will be the most violent, for the air will be forced out of the mine as if by a piston. Take the case of a moderate fall of 20,000 square feet in a 16 feet seam. This would displace or attempt to displace 320,000 cubic feet of air in one second. If the fall were 100 feet thick the pressure, if the air were confined, would be 100 lbs. per square inch, due to actual weight of the rocks.

A covering for pit tops designed to meet the danger

from air-blasts is described in Section III, and so far as the writers are aware, the idea of fitting safety-valves and observation holes in scaffolds over pit tops is a novel one. The precaution appeared advisable in view of the danger from air-blasts. It was not forgotten that the impact of an explosion or a blast would test each dam simultaneously, and is very different from the gradual increase of pressure in a steam boiler. But an air-blast differs from an explosion. It begins more slowly, and though in the end there is an impact with some of the effects of an explosion, the pressure is maintained in the case where the fall extends to the surface or greatly exceeds the thickness of the seam until relieved by an outlet.

In the event of an explosion of gas a vacuum is formed after the explosion causing the familiar back lash. It was considered that the safety valve plates would relieve the pressure, and prevent the foul gas from being forced through the dams into Apcar Pit. Apart from the relief of pressure, it appears to the writers that an easily opened and closed hole through a scaffold is desirable for the purposes of observation, and for ventilation trials without disturbing the scaffolds. The idea might be expanded so as to be suitable for scaffolds upon which it is necessary to put sand and earth. In such a case a cylinder of thin sheet iron should be fixed to the plate as shown in the sketch on Plate III. A hole in the middle of the lid just large enough to admit a safety lamp would be an improvement. This hole might be covered with a lid working on a pivot and fastened with a bolt.

It would, however, be foreign to the object of this paper to do more than briefly indicate the grave danger those who were fighting Charanpur fire ran from air-blasts. Air-blasts and the control of the roof in Bengal coal mines

would be an excellent subject for a paper to be read before the Members of this Institute.

VI.—LESSONS TO BE LEARNED FROM THE FIRE.

This serious fire will not have occurred in vain, if some of the lessons taught by it are learnt by the Managers and Colliery Owners in India, and proper steps are taken to remedy the dangers. The writers particularly desire to draw attention to one danger.

An underground fire may be caused by spontaneous combustion, by the careless handling of lights, by electrical appliances, by shot firing, or by gas or dust explosions The liability of fires originating from these causes will increase as the workings become more extensive. Fires are certain to occur and the question "how are they to be isolated or put out?" is a very pertinent one. The fact that the workings at Charanpur were divided into four main districts by dykes enabled the fire to be conquered. Without these natural damming places, the most strenuous efforts would not have saved Apcar pit.

In considering the inherent dangers of Indian coal-mining, it is necessary to clear our minds of any prejudices due to experience in other countries. The Indian conditions are very different from those which obtain in other coal-fields. The fire dangers only need to be considered in this paper. The extraordinarily strong roof over the seams allows wide galleries to be driven to the full height of the very thick seams, and the practice has been to cut very large coal areas into pillars by such galleries. If the pillars crush out or are burnt out, the roof will not fall until a very large area is unsupported. When the fall takes place, an air-blast is inevitable. Except in a few isolated mines, it has not been the practice to divide the workings into dis-

tricts by leaving ribs of coal. In such conditions, the only damming places would be in the galleries, perhaps 20 feet high and 15 feet wide. A dam of such an area, unless of enormous thickness, would burst under the impact of an air-blast. In any case it would be impracticable to make gas-tight dams in such large galleries in a hurry. Therefore, the only alternative in the case of fire in many Indian collieries would be to stop the pit tops or fill up the shafts. The conditions at the tops of many shafts makes fixing scaffolds very difficult, and filling the pits with earth is a very slow process where the insets are say 20 feet high. Shafts are very numerous and interconnected over large areas, in many cases there being no boundary ribs between mines worked by different owners. Thus, a fire might involve the closing of a group of collieries; and the closing might be permanent if falls extended to the surface. Fire will spread with marvellous rapidity in Indian coal mines because the small local falls of roof which do much to check the spread of fires in other countries are absent. When falls occur in a fire area they will produce air-blasts which will shoot burning gases in all directions, and extend the fire to distant workings. Fortunately provisions against these dangers can easily be made by dividing the areas into districts and panels with ribs of coal between each district and panel. All the galleries cut through the ribs should be small, say not more than 8 feet wide and 8 feet high, and dams should be put in them as soon as coal working in the district or panel is finished. It would be out of place in this paper to discuss in detail the arrangement of such a system of working. It is being practised more or less completely in one or two cases, and it is to be hoped a paper will be read on the subject.

The principal lessons to be learnt from the fire may be summarised :—

(1) The importance of working coal in panels or districts which can be readily isolated from the rest of the mine.

(2) Pit insets to be made of a reasonably small size. Some are 20 feet high and 15 feet wide.

(3) The galleries to be made lower and narrower at places where ventilating stoppings are likely to be required.

(4) The strict prohibition of the use of torches or the lighting of fires underground.

Other important considerations are :—

(1) Managers being prepared to reverse the air-current at short notice.

(2) The advisability of increased supervision during the night shift.

VII.—RESCUE STATIONS.

This fire emphatically drew attention to the fact that none of the appliances, tools and materials required when fighting fire, gas, or water in collieries are kept at any of the mines in the Raniganj and Jharia coal-fields, and that little reliance can be placed upon native subordinate officials in times of difficulty and danger. Coal-mining in Bengal is rapidly extending and becoming more strenuous. To elaborate the great increase in the dangers due to this would be to expound the obvious. The dangers are patent to every intelligent observer. It appears to the writers that preparation to meet them should be made without delay. If each colliery kept appliances it is certain they would in most instances be incomplete and not in order

when required. The cheapest and most efficient plan would be to establish rescue stations at suitable centres in the coal-fields where the appliances could be kept and where the managers could meet from time to time to learn their use. This would also help to establish that *esprit-de-corps* which induces managers at home to offer their services to neighbouring collieries in times of serious accidents.

The most suitable places for the stations would be Sanctoria, Charanpur, Jharia, and Sijua where the mining instructor gives his lectures. Store-rooms could be built near the lecture-rooms. The appliances to be kept should include :—

60 feet of 4″ iron pipes, in lengths ; 4 of the pipes to be fitted with cocks.
10 long tapered wooden plugs.
4 small hand fans.
300 feet of 9″ air-pipes.
100 yards of brattice cloth, 6 feet wide.
500 feet brattice strips (wood 2″ × 1″).
50 light poles, 20 feet long.
20 lbs. brattice nails.
10 lbs. 4″ nails.
6 "prickers," head shaped like a boat hook, handles 12 feet long.
6 rakes with handles 12 feet long.
10,000 wedge-shaped fire bricks 12″ × 12″ × 11″ × 6″.
50 barrels of cement.
20 thin sheet iron plates, assorted sizes.
4 fire-extinguishers.
24 fire hand-grenades.
6 axes with hammer heads.
6 first-class English saws.

At Home and on the Continent of Europe there has been considerable discussion lately with reference to pneumatophores and other apparatus designed to permit the wearer to enter workings filled with noxious gases. Though such apparatus are kept at a large number of Austrian and German coal mines, they are still in the process of evolution, and perhaps it is not necessary to introduce them into India at present.

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APPENDIX.

DIARY OF EVENTS DURING THE FIRE.

Friday, 29th March, 1907.—At about 5-30 A.M.[1] a Sirdar (deputy overman) informed the Manager that a stack of sleepers was burning near No. 4 pit. He had withdrawn all the work people (113 persons) from the workings near pits Nos. 17, 22, and 2. On investigation it was found that a pillar of coal and the coal roof of a gallery were burning at a point two pillars north of No. 4 pit. Coolies would not approach the place, and it was not thought possible to extinguish the blaze. At 6-30 A.M. the fan was stopped. Shortly afterwards dense volumes of black smoke began to issue from pits Nos. 17, 19, and 21. A commencement was made with the building of an air stopping at E in the gallery south of pit No. 2, the only point south of pit No. 17 from which the fire could draw air; temporary fire dams were commenced at A, B, C, and D in the four passages through the dyke connecting the No. 2 pit workings with those from pit Apcar. An attempt was made to reach the two passages through the dyke (the points F and G) north of pit No. 17. Owing to the presence of smoke it was found impossible to reach these connections, and the project of erecting fire-dams in them was abandoned. As an alternative a fire

[1] From enquiries subsequently made it appears that the man came some hours before this, but the servants, not appreciating the urgency of the situation, did not arouse the Manager.

dam was commenced at the point H in the single passage through the dyke separating the workings of pit No. 22 from those from pit No. 20. At 4 P.M. it was possible to approach close to the fire on the south side and it was found that at least five pillars were then burning.

Between 7 and 8 P.M. flames could be seen at pit No. 17, and the headgear became ignited. At midnight the headgear collapsed, and about half an hour afterwards flames burst forth with violence from the pit and continued burning as a bright torch 150 feet in height.

30*th March*, 1907.—The air stopping at the point E was completed, but as the fire was now drawing air from the openings on the north, no diminution of its violence took place. Flames burst forth from pit No. 21, whilst pit No. 24, only 60 feet to the south, was found to be downcasting strongly, and on looking down the shaft the pillars at the inset could be seen burning.

Rough walls 3′ to 4′ thick were completed at the points A, C, D, and H.

31*st March*, 1907.—The temporary dams (see Plate III) at the points A, B, C D, and H were completed. The tops of pits Nos. 12, 20, and 23 were covered with light scaffolds. It was found that the smoke had cleared and it was possible to enter the northern workings by incline No. 13, and to reach the dyke holings at the points F and G. The pillars of coal south of the dyke could be seen burning fiercely. It was not considered prudent to attempt to build stoppings in these holings. All the men were withdrawn from No. 2 pit and a commencement was made with the filling up of pits Nos. 2, 4, and 24 by throwing down earth from the surface.

1*st April*, 1907.—Pits Nos. 13, 24, 2, and 4 were blocked up with earth. The only openings now were pits Nos. 17, 19, and 21. Frequent reversals of the air current took place, flames bursting alternately from pits Nos. 17 and 21. The work of putting in reinforcing fire-dams at the points A, B, C, and D was commenced from the Apcar pit side.

2*nd April*, 1907.—Pit No. 19 was filled up with earth. Pits Nos. 17 and 21 continued to act alternately as upcasts or downcasts, but eventually No. 21 gained the mastery and flamed fiercely. Only a small amount of smoke was now issuing from pit No. 17, and it was found possible to enter the surface inset at the south side and build a scaffold of rails and galvanized sheets over the pit. This had been put in satisfactorily and a small amount of earth had been thrown on

it when a fall took place underground, probably between pit No. 17 and the dyke on the north. The following were the effects of the fall : -

Pit No. 22.	Smoke issued.	Downcasting afterwards.
,, ,, 23.	Light scaffold blown off.	,, ,,
,, ,, 20.	,, ,, ,,	,, ,,
,, ,, 12.	,, ,, ,,	Upcasting ,,
Incline No. 13.	Earth filling blown out.	Smoking ,,
Pit No. 17.	Smoke and sparks emitted; scaffold blown up round the edges.	Upcasting ,,
Pit No. 21.	Flame and smoke shot to a great height.	,, ,,
Pit No. 4.	The arch of the fan drift blown off. Dust emitted.	
Pits Nos. 2, 19, and 24.	Nothing happened.	

Dam at H, 10 feet thick, blown out.

Whilst the closing up of pit No. 17 was being done the workmen employed at dams A, B, C, and D in Apcar pit had been withdrawn from the mine; thus at the time of the air-blast no men were underground. During the afternoon an examination of these dams was made and they were found intact. The pipes passing through dam B were drawing air strongly.

3rd April, 1907.—Early morning. Pits Nos. 25, 22, 20, and 4 were downcasting strongly. Pits Nos. 23, 12, 13, 17, and 21 were smoking strongly.

Pits Nos. 12 and 23 were scaffolded. A commencement was made with the filling of pit No. 20.

At the points A, B, and C reinforcing dams of dry walls with sand filling were completed. The stone air-stopping east of pit No. 18 was broached, and a canvas brattice was erected closing up the galleries south and west of the pit. This had the effect of reversing the ventilation, and the air now passed eastwards from pit No. 18 to the fire dam area, and then south towards pit Apcar. It was then possible to commence work at dam D where previously, owing to the lack of fresh air, it was impossible for men to work. The brick dam at J was

knocked out and a depression, five feet deep and full of water, was found just beyond. Blasting operations to allow this water to run off were commenced.

4th April, 1907.—Early morning. Pits Nos. 12 and 13 were smoking. Pits Nos. 25, 26, 22, 20, and 23 were downcasting. Pits Nos. 17 and 21 were strongly upcasting.

As it was found to be difficult to keep the masons employed at the dams supplied with materials from pit Apcar alone, Pit No. 18 was fitted with a temporary headgear, a pulley block and fibre rope, and materials were lowered by a gang of coolies hauling on the rope.

5th April, 1907.—The blasting operations at J were completed, the standing water run off and a clear road made to dam D. This improved the ventilation to such an extent that, by using high-class candles, it was possible to work at dam D.

First permanent section (5 feet thick) of dam A almost completed. First permanent sections of dams B, C, and D commenced.

6th April, 1907.—During the day explorers descended pit No. 22, and it was discovered that the effect of the air-blast on the second of the month had been to completely level the temporary dam, 10 feet thick, at the point H. Smoke was encountered about 50 yards east of this point. A strong current of air, however, was passing towards the fire area. Pits Nos. 12 and 13 were smoking slightly, and pits Nos. 17 and 21 strongly. The first permanent section of dam D was completed.

7th and 8th April, 1907.—First permanent sections of dams A and C completed.

9th April, 1907.—First permanent section of dam B completed. Incline No. 13 was filled up.

10th April, 1907.—Second permanent sections of dams A and D completed. Pit No. 26 was filled up. Pits Nos. 22, 23, 20, and 12 were scaffolded. Insets to pit No. 17 were blocked up.

11th April, 1907.—Only pits Nos. 25, 17, and 21 were now open. Of these pit No. 25 was downcasting strongly, whilst Nos. 17 and 21 were upcasts.

On the evening of this day the cocks on the pipes in dam B were closed. When open they had been drawing air strongly. All workmen were withdrawn from pit Apcar, and the final sealing of the pits commenced in the following order :—Pit No. 25 was covered by an

iron plate with a circular observation hole, 2′ in diameter, covered by a hinged door. The scaffold at the surface level at pit No. 17 was then plugged up round the edges by throwing down clay and earth from the banking out level. This stopped nearly all the smoke. Finally pit No. 21 was covered with an iron plate similar to that covering pit No. 25 and provided with pipes for pressure gauges. Shortly after this a considerable outward pressure was apparent at all the scaffolded pits.

12*th April*, 1907.—At pit No. 17 a second scaffold consisting of an iron plate was placed over the shaft at the banking out level.

All scaffolds gave evidence of outward pressure, and on opening the cock on the pipes passing through B dam, a strong current of fresh air issued.

20*th April*, 1907.—All scaffolds, particularly that over pit No. 25, were drawing in air. A thermometer lowered to a depth of 30 feet below the plate over pit No. 21 registered 205° F. when drawn up. The pipes at B dam drew in air when the cock was opened.

29*th April*, 1907.—Pits Nos. 17 and 21 seemed rather cooler. A thermometer, designed to register up to 130° F., on being pushed into the sand covering the plate over pit No. 21 registered 125° and was then withdrawn to prevent its being broken by the expanding mercury. A second permanent ring of 5 feet of brickwork was completed at dam B. Preparations were made for inserting the third permanent rings of masonry, 5 feet thick, at dams A and C.

7*th May*, 1907.—A strong smell of fire-stink was found in the gallery at dam D. A chicken after being left in the gallery for a short time showed signs of collapse, but subsequently recovered on being taken into the fresh air. The official who entered the place suffered from headache. A small quantity of water began to come through dam D in several places.

12*th May*, 1907.—A thermometer lowered through the plate over pit No. 21 to a depth of 30 feet registered a temperature of 154° F. Air was being sucked inwards. A thermometer placed in the sand covering the top of the scaffold over pit No. 17 registered a temperature of 128° F.

13*th May*, 1907.—The amount of water passing through dam D had increased perceptibly. No more gas appeared to have been given off, and, although owing to diffusion the smell was noticeable to a much

greater distance from the dam than before, it was not so strong near the dam. Mice were unaffected and no indication of gas was shown on a safety lamp. The pipes at B dam were drawing air.

2nd June, 1907.—By this time three permanent Sections, each 5 feet thick, had been erected at dam B.

Since the final closing of the pits up to the 14th May the scaffolds and the pipes at dam B had been, except for occasional temporary reversals, drawing in air. From May 14th, the contrary was the case. On opening the cocks on the pipes at dam B foul gases issued, and a safety lamp held in front of the pipes was extinguished at once. A mouse placed in the mouth of the pipe was killed in less than a minute.

The amount of water percolating through dam D had not increased. None of the other dams were leaking.

3rd June, 1907.—A thermometer lowered to a depth of 30 feet below the scaffold at pit No. 21 registered a temperature of 138° F.; whilst in the sand on the scaffold at Pit No. 17 the temperature was 110° F.

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DISCUSSION.

Mr. F. J. Agabeg, in opening the discussion, said that since the fire happened all the four dams *A*, *B*, *C*, and *D*, had been strengthened, and still further strengthening was going on. Before this was done the dyke had been cut in such a manner so as to give the arch of the dams a good spring. They were now perfectly gas and water-tight. Mr. Pickering and Mr. Simpson had said nothing about themselves in their paper, but he wished to say that if it had not been for their valuable help and advice Pit Apcar would have been lost. Only those who were at the fire knew the danger all were running. The fire below was a sight never to be forgotten.

As regards the cause of the fire, it was generally rumoured that the fire originated by the spontaneous combustion of the rubbish down the pit, but he could only say

that there was no rubbish there, and the place where the sleepers were stacked was well ventilated, so there could have been no spontaneous combustion. From reliable information since received, it appeared that one of the dyke cutters, who was seated near the sleepers with a naked light, went to sleep keeping the lamp burning. Some creosoted sleepers in the pile caught fire, and set light to the two pillars between which they were stacked, from which the fire spread. When he arrived with Mr. Simpson, five pillars were burning. This statement, in his opinion, ought to remove the idea that the fire was due to spontaneous combustion. In his 30 years' experience he had not known of a fire taking place in this seam from that cause. The damming of pit No. 2 dykes was finished in about three days, this work was going on while the fire was raging within a few feet of the workmen. The draw was so great that the air was hissing through the brick air stoppings like the noise of escaping steam.

After Mr. Pickering's arrival it was decided to strengthen the pit dams from Pit Apcar side, with fire brick and cement. Before this work was commenced steps were taken to choke down the fire, by closing some of the rise air shafts. Work on this was commenced at once. It was while fixing the stopping in No. 17, which had now become a down cast, that the fall or explosion below occurred. The force was so great that it blew the air drift arch on top of pit 4, 150 feet into the air. After this the question arose whether the dams in pit 2 had stood the force of the explosion or air blast. To ascertain this it was decided to explore from Pit Apcar up to the dams.

Mr. Pickering decided that the following gentlemen should form the party: Messrs. Pickering, Simpson, Grundy, Maltby, manager of Charanpore, and Mr. Lea, one of the

managers of a neighbouring colliery; while Mr. E. Forbes and himself were deputed to remain on the pit top and take signals and watch the winding engine, etc. A special code was drawn up for the occasion and every one of them received a copy so that there could be no mistakes made. It was decided that if nothing was heard from the party in three quarters of an hour, he was to come down with a search party. It was a very anxious time as the minutes went on and no signal within the time allowed. It was then that he decided with Mr. Forbes to go below in search of the party. While arrangements were being made they heard the welcome sound of the pit signal, and they then knew that the party were safe. On arrival on top Mr. Pickering informed them that the dams had stood, and that it would be advisable to start on the strengthening of the dams from Pit Apcar side. This work was commenced at once, managers from neighbouring collieries giving a willing hand in the work; while Messrs. Pickering, Grundy, Simpson, Adams, and Griffiths took shifts and turn-about with the other managers, amongst whom he wished especially to mention Mr. Chrystle of the Bengal Coal Co., and Mr. Barrowman of the Equitable. In conclusion he wished to say that he could not express his gratitude enough to all the gentlemen who helped, for without it the whole colliery would have been lost for some time, if not for good. He hoped to open out again in another two months or so.

Mr. Grundy asked whether it would be on this side of the fire area. Mr. Agabeg replied that it would be on the north side of the dyke.

Mr. T. Chrystle, Mr. W. T. Griffiths and Mr. G. F. Scott desired further time for consideration of the paper before discussing it.

Mr. T. H. Ward said that there seemed to be a feeling in the meeting that discussion was to be stifled, and desired to assure the members that this was far from being the case. They were only too glad to hear everything any member had to say, and to publish his remarks. This discussion was not to be considered as then closed. It could be carried on by correspondence, and at future meetings, as was done in other Institutes.

He had seen many pits on fire in England, and in this country, on a large scale; and Mr. Chrystle, he believed, had had considerable experience in South Staffordshire in fighting fires. After all one fire was very much like another. A few days after he took charge of the E.I.R. Collieries as Superintendent, a fire occurred in the Jubilee pit, and, as in the case at Charanpur, the origin was never discovered. He received news that a heading was on fire, and when he got there, he found his staff busily engaged in trying to extinguish the fire. The whole of the end was alight and there was a big red-hot heap of incandescent coal. One of the overmen, a strong big fellow, was rushing with buckets of water to try and extinguish it. The mine had been opened out, and the place was well drained all round so that it was dry. To deal with this fire the speaker at once fell back to where the level into this district came through the rib, and dammed off the level and the return air course, closing the whole district. The dam in the level was to be made so that water would pass along and fill up the "dip" gallery in which the fire was. Some hours afterwards, however, he found that the dam in the level (the intake) had been completed, but that it had been found impossible to "top" the dam in the return air course as a large quantity of gas and smoke came over. This made it evident that the intake dam was not air-tight,

and it was found that, instead of passing the water through the dam by arranging a seal, a space had been left over the water, through which air was passing freely. In 10 minutes after this was put right, the dam in the return was topped without any difficulty.

There were many more ways, than spontaneous combustion, in which a mine can be fired, and it was therefore of great importance that mines should be laid out so that there was a rib to fall back upon. He noticed that the plans of Charanpur showed that the management had not taken full advantage of the natural barrier which the existence of a dyke right through the property afforded. Such a dyke destroyed a lot of coal, but it might be turned into a source of profit if, when it was discovered, the workings were laid out so that it could be used as a barrier. In that way it might be made to save much coal, because a barrier constituted by a dyke need not be so wide as if only a coal barrier had to be left. Such a dyke should not be treated as the management at Charanpur had treated it—by driving more than the necessary number of openings through it. It would be seen from the position of the dams, and the plans of the dams, that large excavations had been made in the dyke. In one place an intersection of two drivings was arranged right in the dyke. That should not have been done. The plan of the workings should have been modified when the dyke was struck, and such a costly intersection entirely avoided. The cost of the dams must have been largely due to the unnecessary excavations made in this dyke in this natural barrier. For instance, one or two places only need have been driven through the dyke, and they should have been limited to a section of $6' \times 6'$, or at most, if a double line of rails had to be accommodated, to $8' \times 6'$ in height. To stop up such places

would have been an easy and very inexpensive affair. These were serious considerations, but an even more serious consideration was the fact that the workers would have been exposed for so much shorter a time. No fire underground could ever be tackled without some risk, and often very great risk, to life. In the Indian conditions, owing to the enormous areas held up, and the vast cubic contents of these areas, due to the thickness of the seams, the danger of gases of very high temperature being driven out on to the workers, by falls taking place in the district on fire, was very much greater than in England, where indeed such a conflagration as was seen in Charanpur is rare. In South Staffordshire they had to deal more frequently with smouldering fires, and the gas given off in those cases was more likely to be of a terribly poisonous nature—containing the deadly CO—than had been found to be the case in India. The speaker had, however, many times seen incandescent coals loaded up in South Staffordshire, and sent out of the pit.

The Charanpur case illustrated what the speaker had always advocated in India—the laying out of the mines so that fire from whatever cause could be dealt with. In one mine under his charge, where fire is most likely to break out, he had sand and bricks stacked underground, near the openings in the ribs, so that the loss of time in collecting these materials, and sending them down, was saved. Such arrangements tended to minimize the risks the staff must run in dealing with these much-to-be-dreaded catastrophes.

In dealing with fire underground the risks the workers had to run were often sufficiently great to make it very desirable to have only volunteers. In South Staffordshire there was never any lack of volunteers, and he had dozens of

times seen men risking their lives, and working harder than they had ever done in getting their own living. He had seen stoppings put in under very arduous conditions: when each man ran in with a trowel full of mortar, or sand, in one hand, and a brick in the other, with a towel round his mouth, and a rope tied round his waist, by which latter he was hauled out if he collapsed. In those cases every man could nicely appreciate the risks he ran, because he had experience of those risks all his life; but in this country the natives who followed one were absolutely ignorant of the risks, and it would be quite impossible to enlighten them. It was, therefore, impossible to avoid the great responsibility of leading them into such dangers by calling for volunteers. In this connection the speaker remembered what he had to do when the fire underground at the E. I. R Collieries broke out in the early eighties. A set of "voys"(South Staffordshire for temporary dam) had been put in each opening, but these had sunk, and "stink" had come over the crack formed along the top of each dam. He knew this, because he had inspected the dams in the morning, and, finding this condition, had ordered the cracks to be plastered. This had not been done; or rather a lot of women had been put on, and told to plaster the dams. They, following immemorial custom, began to "lip" the walls, *i.e.*, they started in the centre and plastered in circles increasing in diameter in the manner in which they treat the walls of their houses. This process left the crack along the top untouched, and the mine had gradually been fouled. The speaker got together a dozen young fellows each armed with a basket of well-puddled clay—nothing else. These people followed him into what might possibly have been a death trap. They had some 400 yards to travel up an inclination to 1 in 5. The atmosphere was laden with

"stink," and they were all more or less breathless when they arrived. Half an hour's work in stopping up the crevice along the top of some 5 or 6 dams resulted in a second reversal of the current; the rest of the dams began again to "draw," and the atmosphere of the mine improved. They were all very ill for a few hours afterwards but saved the situation. Had South Staffordshire men been employed there would have been no responsibility in leading them; but in the circumstances it was very great. The news received was that several men had been overcome by gas in their working places while cutting coal, so that it was clear that the atmosphere of the mine was extensively fouled. As the mine had been entirely vacated when they got there, there was only one course open to him—to go down and see if the atmosphere of the mine would allow time to make up the dams. When he had seen them in the morning they had been "drawing" (*i.e.*, taking in air); and it was clear that the direction of the current had been reversed and that the atmosphere of the mine must rapidly get worse.

He proposed a vote of thanks to Mr. Pickering and Mr. Simpson for their admirable and instructive paper. He saw Mr. Pickering at work at Charanpur, and was deeply impressed by the whole-hearted way he went to work. It was his impression that it was Mr. Pickering's advice and personal example and assistance which had saved the mine.

Mr. F. J. Agabeg seconded the vote of thanks to Mr. Pickering and his co-author, Mr. Simpson. In doing so he also wished to thank the other gentlemen who helped at the fire. Mr. Chrystle was rather modest and would not say what he did, but it was largely due to his advice, based on

his experience with a number of fires at Staffordshire, that the fire was got under so quickly.

Mr. Pickering, in replying to the vote of thanks, said that he did not wish to take the credit of extinguishing the fire himself, but desired to associate himself with his colleagues and the gentlemen who stood by him at that trying time. He could never wish to be associated with better men and better pluck.

Further discussion was then postponed until the next meeting.

THE RETIREMENT OF MR. PICKERING.

Mr. T. H. Ward then read a letter from Mr. Pickering acknowledging his election as an Honorary Member of the Institute.

Mr. G. F. Scott, speaking on behalf of Mr. H. H. McLeod, desired to refer to the approaching retirement of Mr Pickering. He believed he was giving expression to the feelings of every member of the mining community and all connected directly or indirectly with the mining industry in saying that they contemplated the retirement of Mr. Pickering with unfeigned regret. It was generally thought that Government would make special efforts to retain the services of an officer who had so successfully filled a difficult post with such credit to himself and to Government. Mr. Pickering had successfully introduced the working of a Mines Act which was fraught with difficulties and danger, and the process had been accompanied by a total absence of friction which was at once a high testimonial to his ability and to his unfailing tact. But it was not alone to his official capacity that they wished to bear testimony. Mr.

Pickering possessed personal qualities which endeared him to all with whom he has come in contact, and it will not be as the official inspector alone that Mr. Pickering will be remembered; not as the phanton ogre that some had mentally pictured—waiting to come down heavy-handed on the temporary lapse of some harassed and overworked manager. It would be as the real friend and sympathiser of mine managers that he will be gratefully remembered—the man who had correctly interpreted the true spirit of the Act. Both Mr. Pickering and Mr. Grundy had proved themselves invaluable where great mining risks were involved, readily placing their knowledge and experience at their disposal so as to ensure the right action being taken at the right moment. They were faced with the prospect of a break in the continuity of these pleasant relations, and the loss would fall as heavily upon Government as upon themselves, and at a time when the mining industry was passing through a very critical phase and could ill afford to lose men who have their hands on the pulse of a great industry. These were the views of the Mining Association, and he hoped that he had correctly interpreted the sentiments of the mining community. He suggested that their united views should be communicated to Government.

Mr. W. Miller endorsed these remarks and thought that the Chief Inspector of Mines had not made a single enemy. He had worked the Mines Act in the way it ought to have been worked when first introduced into a new country, where mining, probably, was not on the same level as in England, and that was a difficult thing for an Inspector just coming out from home. Indian mining differed considerably from mining at home, and the introduction of legislation into Indian mining was equally as difficult as mining generally. He thought he expressed the feelings of the

members present, and of everyone implicated in the mining industries, in saying that it was with the deepest regret that they were parting from Mr. Pickering. Personally he thought they had been to a considerable extent slack in this matter. When they first heard of Mr. Pickering's contemplated departure, they ought to have taken steps to see if they could not have induced Mr. Pickering to alter his mind; but things had then gone too far. Before he went, something ought to be done, and there was no doubt but that a movement only required to be started and it would be well supported. It was not necessary for him to add more. He had worked with Mr. Pickering in a business capacity so far as the Mines Act was concerned and had met him socially. Always he found him to be open to reason and moderate in his ideas and views.

Mr. T. H. Ward moved that Mr. McLeod's suggestions be adopted, and that the Secretary be instructed to inform the Government of those views which, he was sure, were endorsed by everyone present. He had been nursing the hope that Mr. Pickering would re-consider his decision to leave the country, and even then he hoped it might be possible for him to remain.

Mr. Agabeg seconded this proposal which was carried unanimously.

Mr. Pickering replied that he greatly regretted having to leave India. He had only been there for three years and in that time he had seen a great deal—many men, many things and many mines. The more he saw of India, the better he liked it, and it is very painful for him to sever his connection with the country. As regards the Mines Act he would say very little. He believed that if the Act were properly administered it would prove very valuable to the owners of mines, and to the mines because

it established managers with certain qualifications which every man, who is responsible for a mine, should have. Of course there would be times where there would be friction between inspectors and mine-owners, but he was sure he expressed the views of all inspectors of the Mining Department in saying there should be efficiency among the managers. If the rules were not properly administered there was a danger of the general standard of mining being lowered. Mr. Grundy's name had been mentioned in association with his own. He was the pioneer of mining in India and should be associated with himself in response to this vote of thanks for which he was deeply grateful.

Mr. Thomas Adamson's paper on the "Chelsea Electric Power Generating Plant" was then read in abstract by the Honorary Secretary. The paper is as follows :—

The Chelsea Electric Power Generating Plant.

BY

Mr. Thomas Adamson.

As electric power is being introduced into the working of Indian mines, a description of the Chelsea power station, as seen in February 1907, may be of interest to the members of this Institute. This plant is the largest of its kind in England, and is only equalled by one in New York. The power-generating house is situated on the north bank of the River Thames, at Chelsea, in the west end of London.

The power generated is used for working the trains on the District Railway (which until two years ago was worked by steam locomotives); the Baker Street and Waterloo Railway; the Great Northern, Piccadily and Brompton Railway; and the Charing Cross, Euston, and Hampstead Railway; some of the tramways in and around London; and for lighting purposes.

The current generated at Chelsea is three-phase and is delivered at a current pressure of 11,000 volts, and a frequency of 33⅓ cycles per second, to 24 sub-stations distributed along the route of the railways worked by it. The largest sub-station is that at Charing Cross.

With the exception of the oil-cooling, and coal-handling plants, all the generating plant, including the boilers (64 in number), is contained in one building, measuring 453 feet in length, 175 feet in width, and 140 feet in height above ground level.

The engine room is 453 feet in length by 75 feet in width, and contains the following, *viz.*:—

8 Turbo-generators, with condensers and air-pumps.
4 Exciter engines and dynamos.

Generators.—These comprise eight 5,500 K.W. Westinghouse steam turbines, direct-coupled to Westinghouse alternators, generating three-phase current at 11,000 volts. These units run at a speed of 1,000 revolutions per minute.

The turbines are of the single cylinder double-flow type. The steam enters at the centre of the engine at a pressure of 165 lbs. per sq. inch, and passes through a series of nozzles and impulse blades until the exhaust is reached, then into the condenser. As the steam enters at the centre of the cylinder and flows both ways, the shaft is kept in equilibrium, and end thrusts eliminated.

The three-phase alternators are of the revolving field type, and have a normal output of 5,500 K.W., *i.e.*, 289 amperes per terminal at 11,000 volts.

The 11,000 volt current, generated at the power station, is transformed and converted in the sub-stations to continuous current at 600 volts, at which pressure it is used for driving the trains on the railways. Other transformers in the sub-stations are provided for changing the high pressure current to 220 volts for lighting purposes.

In Charing Cross sub-station alone the transformation from polyphase to direct current is effected by four 1,500 K. W. rotary converters.

Switch Gear.—The switch gear at the power station is very extensive and complicated.

The 11,000 volt current is controlled by oil switches,

the contacts being made in oil instead of in air, as is usually done in low volt currents. The total length taken up by the switch boards and gear is over a quarter of a mile ; it extends over three galleries running the full length of the engine room

Oil Supply.—Oil is not used in the turbines, but only in the bearings. The turbo-generator bearings are of cast-iron with babbit metal lining. The turbine and generator shafts are connected by a coupling of the flexible or claw type, which runs in oil. This coupling transmits the full power of the turbine, and has sufficient latitude to allow the generator and turbine shafts to revolve around independent centres, so that any want of exact alignment is immaterial.

Centrifugal pumps driven by motors supply oil under pressure to the bearings. Each turbo-generator requires 33 gallons of oil per minute to be circulated through its four bearings, making 264 gallons per minute when the 8 turbines run simultaneously. The result is that besides lubricating the journals, the rapidly circulating oil carries away the heat evolved. For this purpose, a complete circulating system, similar to that of steam condensing arrangements, has been provided. At the east end of the main building is the oil supply house ; it has three floors, the height of this building is about 50 feet. The ground floor is occupied by three large oil coolers. The second floor is taken up by a feed water storage tank, and the third floor by oil filtering and gravity tanks. The gravity tanks are 30 feet above the level of the turbo-generator shafts. Oil is conveyed from the gravity tanks by six-inch diameter pipes down to the engine-room, and connected by branch pipes with the four bearings of each turbo-generator. The oil through this gravity head is

forced through the bearings, and returns by a second oil main by gravity to the tanks on the ground floor of the oil-cooling house. From there electrically driven centrifugal pumps drive the oil through the coolers, up to the filters and gravity tanks, on the top floor. The coolers are an arrangement of pipes around which water from the river is made to circulate.

Condensing Plant.—As the turbines are of the double-flow type, the exhaust is taken from each end of the cylinder to the condensers by two exhaust pipes which pass from the underside of the turbines to the condensers in the basement. The exhaust pipes are 44 inches in diameter. Valves are placed in the exhaust range, and arranged, so that in case the condensers are off at any time, the exhaust steam can be led direct into the atmosphere by means of a range of pipes, extending for nearly the full length of the building, which terminates in three vertical pipes five feet in diameter, fixed alongside the chimneys, to a height of over 100 feet.

There is, for each turbine, a condenser of the surface condensing type. The circulating water is obtained from the river Thames through two ranges of 5′ 6″ diameter pipes, which connect on to each condenser by branch pipes 20 inches in diameter. Each condenser is provided with a 20-inch circulating Worthington pump driven by a three-phase motor. There is also provided for each condenser a Worthington electrically driven dry air vacuum pump 24″ × 18″, and a 4″ pump by the same maker, the latter for pumping the water from condensation, to the hot well. The vacuum maintained by the condenser pumps is equal to 27 inches of mercury.

Exciter Engines.—This plant consist of four sets of engines and dynamos, aggregating an output of 600 K.W.

The engines are compound and coupled direct to a continuous current British Thomson-Houston dynamo. When run at 375 revolutions per minute, each engine developes 200 h.-p. and generates a current of 125 volts. The generators are rated to take 25 per cent. overload for two hours without sparking.

Boilers.—The steam for driving this plant is generated by 64 water-tube Babcock and Wilcox boilers. They are arranged on two floors, one above the other, and two rows of 16 each on each floor, with a wide space between each row. The boilers are connected up into eight groups, of eight boilers in each group, one group being required for each turbo-generator set.

A mechanical stoker is attached to each boiler, of the travelling bar type, the rate of feed being regulated by a worm and worm wheel arrangement. These mechanical stokers enable inferior coal to be used. Nothing larger than what will pass through a $\frac{5}{8}$-inch spaced screen is charged.

The boilers are all fitted with Babcock and Wilcox superheaters. Green's economisers are used throughout, and the plant is said to be the largest single installation in the world, as it comprises a total number of 9,216 tubes. They are erected directly behind the boilers and over the main flue.

Each group of boilers has its own steam-pipe range, which is of lap-welded steel 14″ diameter ~~chimneys~~. The gases after passing through the economisers pass to the four chimneys. Each chimney is 19 feet in diameter at the base, and 275 feet in height above ground level. The foundations go down to a depth of 35 feet into the London clay.

Boiler Feed Pumps —In the ground floor of the boiler-house are eight boiler feed pumps—seven made by the Worthington Steam Pump Company and one of the Heisler

type. They are all compound engine pumps with cylinders 16½″ and 26″ in diameter; the last-named pump is also worked condensing. Each pump is capable of delivering 300 gallons of water per minute into the boilers. The feed water is taken from an 8½-inch artesian well 575 feet in depth. As a precaution against this water-supply failing, water can be taken from the public water-supply mains or from the River Thames.

Coal Handling Plant.—This is most interesting, as the details have been most carefully designed with the object of minimizing the number of persons necessary for handling the large quantity of coal required for steaming purposes. The plant is capable of handling 800 tons of coal per day of 12 hours.

The coal is brought by barges up the river into the barge basin. Two large gantry electric travelling cranes span the barge basin. Grabs are worked from the top girders of the cranes; each grab lifts 1½ tons of coal at a time from the holds of the barges. The grabs with their loads are moved to one side of the basin, where the coal is dropped into a weighing machine, from which it descends through hoppers on to a travelling belt 30 inches in width, of an indiarubber composition. This belt runs on rollers, with inclined rollers on each side, which tilts the edges of the belt up and gives it a hollow section, so that it may hold the coal. The coal is carried a distance of 190 feet by this belt and deposited into another hopper, from which it is raised by a twin bucket elevator to the top of the boiler-house building, a distance of 145 feet in vertical height, and there deposited into another hopper. The coal is taken from this hopper through sliding doors on to two belts, 24″ in width, and is conveyed by them and distributed into hoppers running almost the full length of

the building. Under each of these two belts is a narrow gauge line, on which runs a specially designed carriage for lipping up the belt so as to drop the coal into any part of the hopper required. The first-mentioned belt is driven by a 15 h.-p. motor, the twin elevator buckets by two 30 h.-p. motors, and the last-mentioned two belts by two 20 h.-p. motors.

The coal is conveyed from this large hopper through pipes on to the mechanical stokers underneath. The whole of the coal is handled, from its being lifted out of the barges until it is landed into the last-named hopper on top of the building, by three men.

The ashes from the fires fall into hoppers under the firing floor, whence they are led away by small trucks, and tipped into barges or other receptacles at the west end of the building.

The present daily coal consumption at this station is about 400 tons.

The introduction of turbines into so important a power-station as that at Chelsea gives further proof of the progress that is being made with that class of machinery. The wear and tear is certainly less in this class than is the case with reciprocating engines, and the absence of knocking and thumping, which sooner or later makes itself heard in the latter, cannot take place in turbines.

The 7,500 h.-p. turbo-generator set occupies a bed only 49′ 0″ in length by 12′ 0″ in width.

Provision has been made in the engine-house for two more units of 7,500 h.-p. each and one of half that capacity. This, when added, will bring the total capacity to 80,000 h.-p. (brake horse-power) with a considerable margin for overload. The present plant is not being worked up to its full capacity; only between the hours of 5 P.M.

till 8 P.M. is it run to anything like its full capacity. This is the time in which the railways are busiest. There are about 100 motors driving the auxiliary plant in this station, *viz.*, air and circulating pumps, stokers, conveyors, elevators, oil pumps, switches, etc. These are controlled from the auxiliary switch board, which is mounted on the east end of the house. The current for driving these motors is of 220 volts, obtained from step down transformers in the power-house. In addition to the power required for working the 70 miles of railway, and the tram service supplied, there were 233,305 lamps on this system on the 31st December 1906.

In conclusion, the author expresses his indebtedness to Mr. A. C. Kelly, of the British Westinghouse Electric and Manufacturing Company, for his courtesy and for the trouble he took in accompanying him over the Chelsea power-station, and for the information he subsequently placed at his disposal; and to Mr. W. H. Heaton, engineer at the power station, for the assistance he so kindly gave.

A vote of thanks to the author was passed, and discussion of the paper was postponed.

After a vote of thanks to Mr. Agabeg for the use of the Club premises, and to Mr. Ward for occupying the chair, the proceedings terminated.

Photo by F. B. Maltby.

FIG. 1.—**Pit No. 17 before the fire.**

Photo by P. Mulvenell.

FIG. 2.—**Pit No. 17 whilst the fire was in progress.**

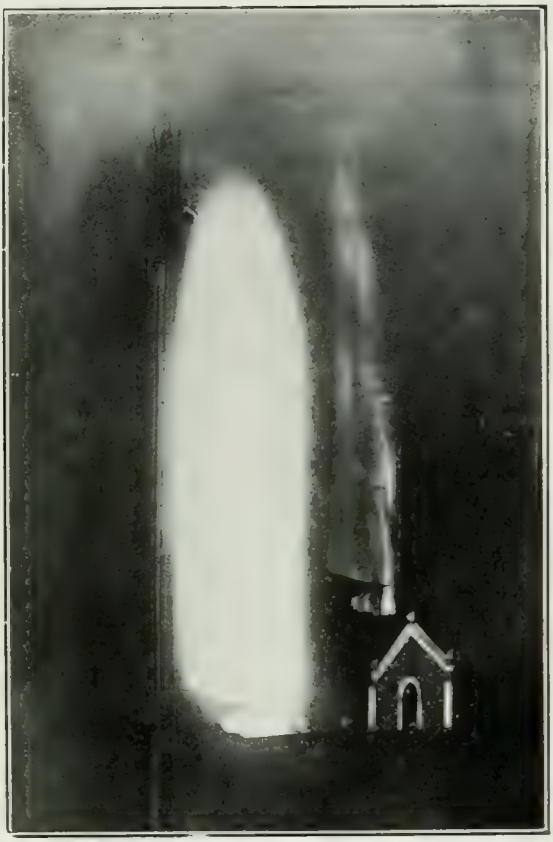


Photo by P. Mitchell.

FIG. 3.—**Flame issuing from No. 17 Pit.**

Photo by P. Mitchell.

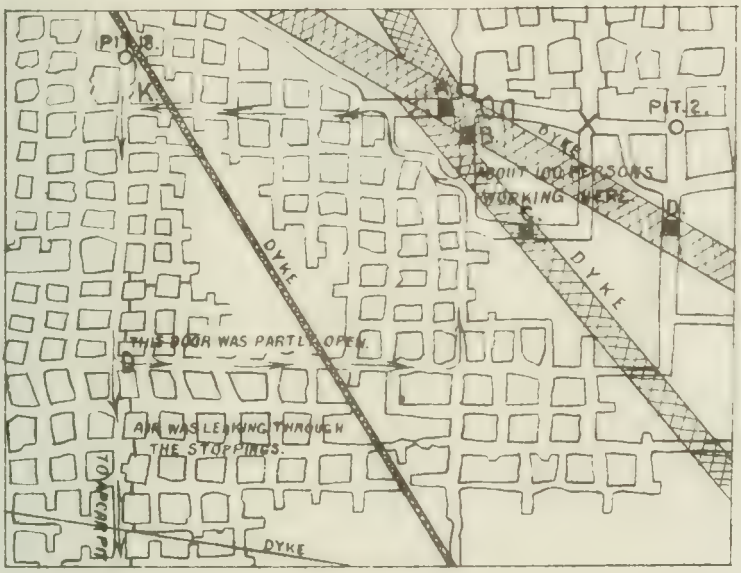
FIG. 4.—**Smoke issuing from Pits Nos. 21, 19 and 17.**

Photo by P. Mitchell.

FIG. 5.—**Smoke issuing from Pit No. 21.**

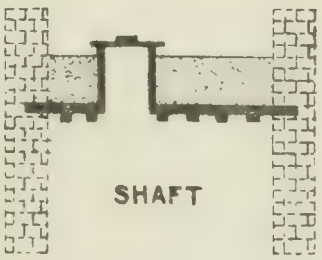
Photo by P. Mitchell.

FIG. 6.—**Smoke issuing from Pits Nos. 19 and 21. No. 2 Pit in the back-ground.**



SKETCH ILLUSTRATING THE AIR WHIRLPOOL

SET UP WHEN THE STOPPING AT K WAS BROACHED



SKETCH OF IMPROVED OBSERVATION SCAFFOLD

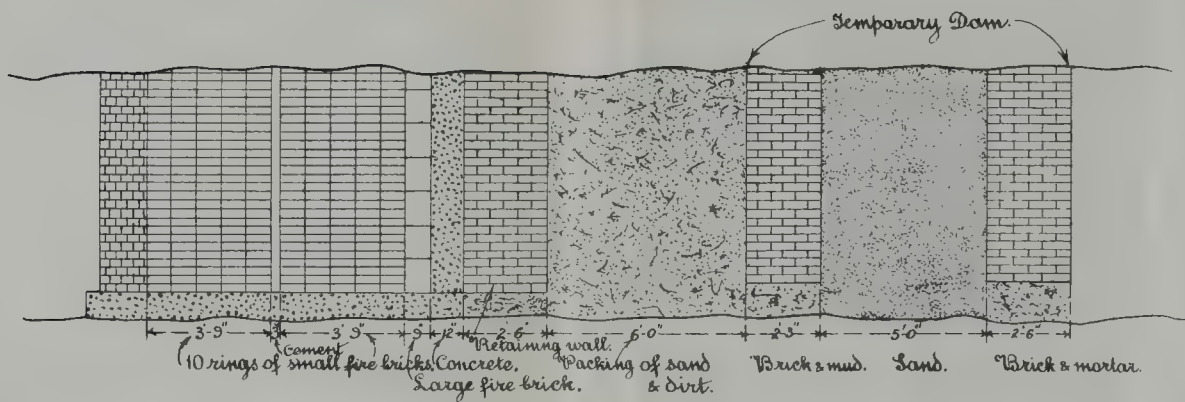
MINING AN

PICKERING AND SIMPSON:

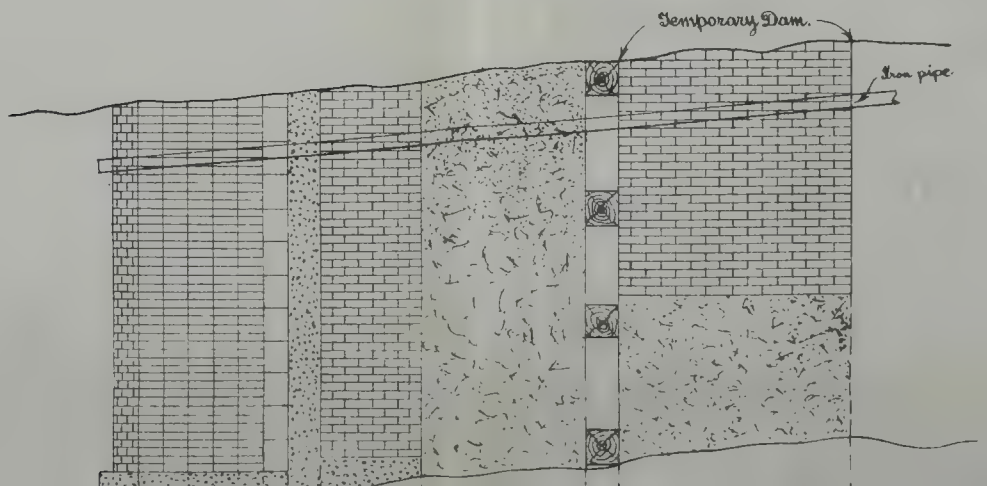
FIGHTING A COLLIERY FIRE.

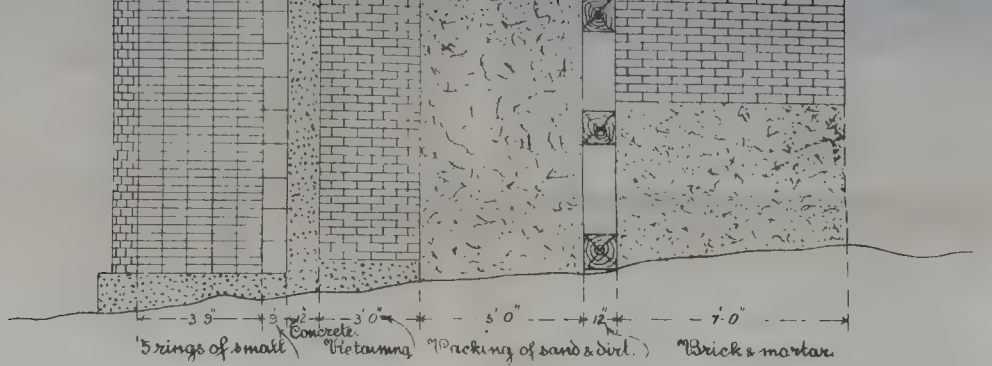
LONGITUDINAL SECTIONS OF THE FIRE DAMS AT THE TIME WHEN THE PITS WERE CLOSED.

DAM A.

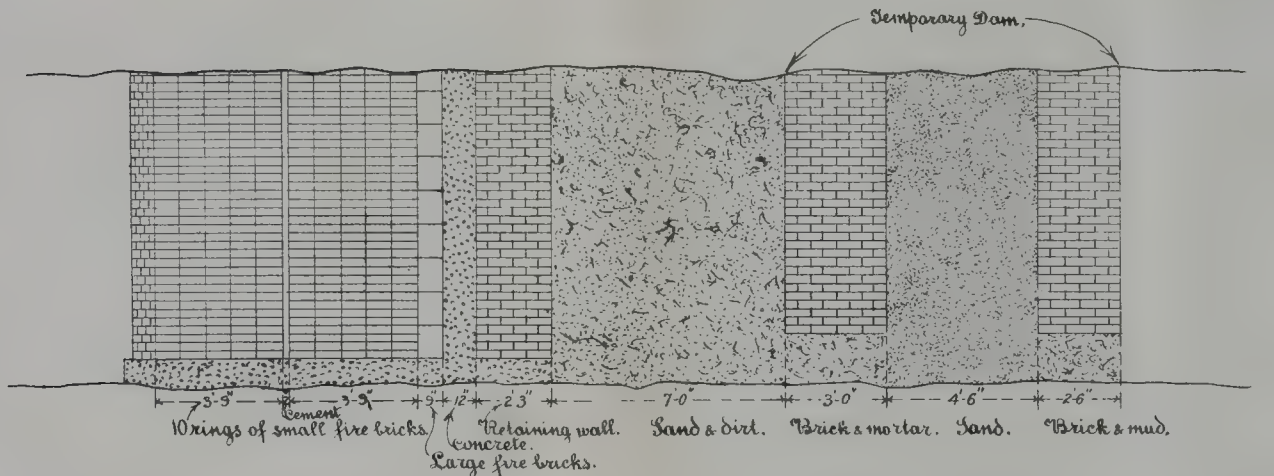


DAM B.

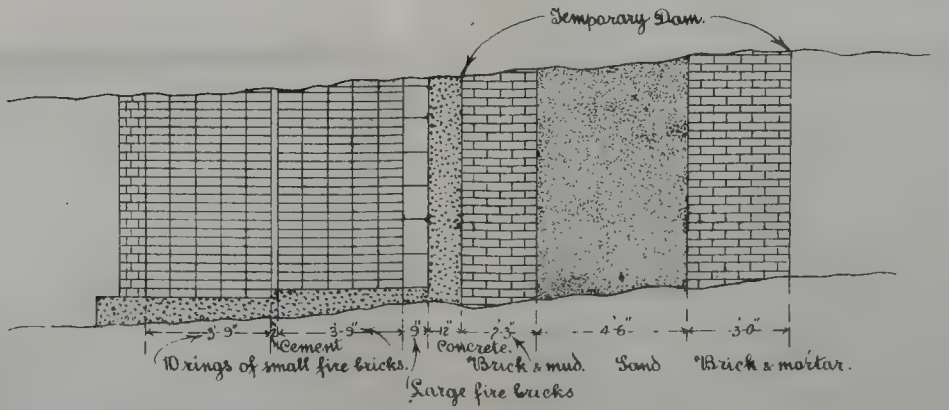



3'9"
9"
2"
3'0"
5'0"
12"
7'0"
5 rings of small
Concrete.
Retaining
Backing of sand & dirt.
Brick & mortar.

DAM C.


Temporary Dam.
3'5"
3'5"
9"
12"
2'3"
7'0"
3'0"
4'6"
2'6"
Cement
10 rings of small fire bricks
Retaining wall.
Concrete.
Large fire bricks.
Sand & dirt.
Brick & mortar.
Sand.
Brick & mud.

DAM D.


Temporary Dam.
3'9"
3'5"
9"
12"
2'3"
4'6"
3'0"
Cement
Concrete.
10 rings of small fire bricks.
Brick & mud.
Sand
Brick & mortar.
Large fire bricks

CHARANPUR COLLIERY.

MINING AND GEOLOGICAL INSTITUTE OF INDIA.
Transactions Vol. II
Plate IV

PICKERING AND SIMPSON
MINING & COLLIERY AGENTS

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TRANSACTIONS

of the

MINING and GEOLOGICAL INSTITUTE

of

INDIA

Vol. III.

EDITED BY

THE

HONORARY SECRETARY.

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1909.

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Transactions of the Mining and Geological Institute of India.

The annual general meeting of the Mining and Geological Institute of India was held in the rooms of the Asiatic Society, Park Street, Calcutta, at eleven o'clock, on Friday, 31st January, 1908. The chair was taken by the President, Mr. T. H. Holland, F.R.S. After declaring the meeting opened and announcing that his term of office expired at the present meeting, he called upon the Honorary Secretary, Mr. H. G. Graves, to read the Report of the Council. While this was being done Major Hughes and Mr. Roberton were appointed scrutineers to deal with the voting papers for the election of the new President, members of Council and officers of the Institute for the following year.

REPORT OF COUNCIL, 1907.

The Council have the honour to present the second annual report on the working of the Mining and Geological Institute of India.

2. During the year the membership has largely increased, as is shown by the following table :—

	1907.	1906.	Increase.
Patron	1	1	..
Ordinary Members ..	187	156	31
Associate ,, ...	16	8	8
Associates	6	3	3
Honorary Members ..	8	3	5
Subscribers	6	2	4

3. Meetings of the Institute were held as follows :—

Annual General Meeting, Calcutta, 26th January, 1907.
Ordinary General Meeting, Calcutta, 27th January, 1907.
,, ,, ,, Asansol, 1st July, 1907.

It was also intended to hold a meeting at Gondia and Balaghat on the 14th and 15th of December, 1907, but, owing to the limited response, it was unfortunately necessary, at the last moment, to postpone this meeting.

4. The following papers were read and discussed :—

(*a*) Sampling of Ores and Bullion ..	By Major F. C. Hughes.
(*b*) Premature Explosions of Powder	,, Mr. James Grundy.
(*c*) Waste in Bengal Coal Mining ..	,, Mr. J. White.
(*d*) Fighting a Colliery Fire ..	,, Messrs. W. H. Pickering and R. R. Simpson.
(*e*) The Chelsea Electric Power Generating Plant	,, Mr. Thos. Adamson.

5. Three parts of the "Transactions" have been issued, forming Parts 3 and 4 of Volume I, under the editorship of Mr. E. H. Roberton; and Part 1 of Volume II, under the editorship of the Honorary Secretary.

6. Five Council Meetings have been held during the year for election of members and transaction of the current

business of the Institute. The work of the Raniganj Map Committee has made favourable progress.

7. The prize offered by the Government of India for the best paper read before the Institute was awarded to Mr. L. L. Fermor for his paper on "Manganese in India."

8. The financial statement shows that the position of the Institute is satisfactory. The revenue of the Institute for 1907 was Rs. 7,514-7-4, the expenditure Rs. 4,296-8-9, leaving a balance of Rs. 3,217-14-7. In addition Rs. 1,140, the realisation of entrance fees, has been credited to Capital.

FINANCIAL STATEMENT for the year ended 31st December, 1907.

	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.		Rs.	A.	P.
CAPITAL ACCOUNT—																
Balance of last year's account ..	..	..	..	..	..	..	4,950	0	0				Cash with the National Bank of India, Ld.	4,769	10	0
Entrance fees of 31 Ordinary Members	..	..	..	930	0	0										
.. ,, 8 Associate Members	..	..	..	120	0	0							Cash with the National Bank of India, Ld. (Fixed Deposit) ..	8,000	0	0
.. ,, 3 Associates ..	..	..	..	90	0	0	1,140	0	0							
										6,090	0	0	Cash with Honorary Secretary ..	70	15	0
RESERVE ACCOUNT—													,, ,, ,, Treasurer ..	18	9	6
15 Life Members' subns. paid in advance	..	..	..	..	..	..	2,280	0	0	..	..	..	Outstanding subscription for 1907	720	0	0
3 Ordinary Members' subn. ,, ..	..	..	..	..	..	..	90	0	0	..	..	..	Value of Publications in Stock ..	400	0	0
										2,370	0	0	Outstanding Bills	160	0	0
LIABILITY SUSPENSE	..	..	..	..	..	..	..	..	..	3	8	2				
REVENUE ACCOUNT—																
RECEIPTS.																
Balance of last year's account ..	..	..	..	..	..	..	2,457	11	9							
SUBSCRIPTIONS for 1906—																
2 Ordinary Members @ Rs. 30, Rs. 60-0																
1 ,, ,, .. 15 ,, 15-0																
2 Associate Members ,, 15 ,, 30-0																
1 ,, ,, ,, 7-8 ,, 7-8																
	112	8	0													
SUBSCRIPTIONS for 1907 —																
183 Ordinary Members @ Rs. 30, Rs. 5,490-0																
4 .. ,, ,, 15 ,, 60-0																
16 Associate Members @ Rs. 15 ,, 240-0																
6 Associates ,, 30 ,, 180-0																
6 Subscribers ,, 30 ,, 180-0																
	6,150	0	0													
				6,262	8	0										
Interest from the National Bank of India, Ld.	..	..	..	356	11	10										
Sale of Books	..	..	..	895	3	6										
				7,514	7	4										
EXPENDITURE.																
Advertising, Printing and Stationery ..	1,954	9	6													
Postages and Telegrams	277	13	3													
Dinner account	423	4	3													
Raneegunge Coal Field Geological map account	554	5	0													
Charges, General	406	8	9													
Establishment	480	0	0													
Law Charges	200	0	0	4,296	8	9	3,217	14	7	5,675	10	4				
TOTAL Rs. ..	..	..	..	..	..	..	..	..	..	14,139	2	6	TOTAL Rs. ..	14,139	2	6

Examined and found correct.

R. P. ASHTON

Mr. R. P. Ashton, the Honorary Treasurer, then presented the financial statement of the Institute for the year 1907 (see page 4) and stated that it was in the same simple form that was submitted last year and therefore did not require much explanation, as the finances were in a sound position. The capital account had increased from Rs. 4,950 to Rs. 6,090 by the addition of Rs. 1,140 as entrance fees. The reserve increased from Rs. 1,560 to Rs. 2,370, and was made up of life-members' subscriptions and other subscriptions paid in advance. Transfers were made annually from reserve to revenue account of the equivalent of what the life-members would pay if they paid annually. Revenue receipts had increased from Rs. 5,398 to Rs. 7,514, and revenue expenditure from Rs. 2,940 to Rs. 4,296. The balance of receipts over expenditure had increased from Rs. 2,457 to Rs. 3,217, and the sale of publications from Rs. 443 to Rs. 895.

There were funds in hand consisting of Rs. 8,000 on fixed deposit with the National Bank at 4 per cent., and Rs. 4,679 in current account. The funds of the Institute were increasing, and the Council would be glad of suggestions for their utilisation.

The Council is of opinion that a lending library might now well be considered. The books of such a library would be acquired out of revenue account but the housing and furniture required for such a library might properly be provided out of block.

The President then opened the following:—

REPORT OF A MEETING OF THE JUDGING COMMITTEE ON PAPERS.

Present.—Messrs. G. C. Leach, E. H. Roberton and H. G. Graves.

The papers considered were :—

1. "Solid Rope Cappings," by Mr. T. H. Ward.
2. "Sidings at the Top of Self-Acting Inclines," by Mr. T. H. Ward.
3. "Sampling of Ores and Bullion," by Major F. C. Hughes.
4. "Chelsea Electric Power Plant," by Mr. Thos. Adamson.
5. "Premature Explosions of Powder," by Mr. Jas. Grundy.
6. "Fighting a Colliery Fire," by Messrs. W. H. Pickering and R. R. Simpson.
7. "Mica," by Mr. A. C. Dickson.
8. "Mine Dams," by Mr. W. T. Griffiths.

The Committee resolved that as the papers by Messrs. Dickson and Griffiths had not been read, they should be considered as of the year 1908 and the decision should be given on the other six papers. After discussing those papers it was unanimously decided that the paper on "Fighting a Colliery Fire," by Messrs. W. H. Pickering and R. R. Simpson, was the best and that it was worthy of the prize of Rs. 500 offered by the Government of India.

(Signed) E. H. Roberton.
,, G. C. Leach.
,, H. G. Graves.

The undersigned members of the Committee, who were unable to be present at this meeting, concur in the award.

(Signed) G. F. Adams.
,, R. G. M. Bathgate.

This award was confirmed with acclamation by the members present at the meeting, and the Secretary was directed to communicate the result to the winners who were unfortunately unable to be present.

Mr. R. P. Ashton then rose to obtain the final assent of the members to the incorporation of the Institute under the Indian Companies Act of 1882 and the memorandum and articles of association. After quoting the by-law which determined the condition under which alterations can be made, he stated that a copy of the proposed memorandum and articles had been sent to all members entitled to vote, and that notice had been inserted by advertisment of their intention. There was only one slight alteration of any importance to be made in the printed proposal, and that was to allow ex-presidents of the Institute to become ex-officio members of Council.

Accordingly he put the following resolution :—

"That the draft memorandum and articles of association, which has been circulated to the members, be altered by the addition to clause 20 of the articles of the words "Past Presidents shall be ex-officio additional members of Council" ; that the memorandum and articles thus altered be signed by the President and adopted by the Institute as the memorandum and articles of association ; and that the Institute be registered under the Indian Companies Act of 1882 under the title of the Mining and Geological Institute of India."

On being seconded by Mr. F. J. Agabeg this resolution was passed without a dissentient vote.

The Scrutineers, Major F. C. Hughes and Mr. E. H. Roberton, now reported that the following gentlemen had been elected for the forthcoming year :—

President.—W. Miller, General Manager, Equitable Coal Company.

Vice-Presidents.—P. Bosworth-Smith, Superintendent, Tank Mine, Kolar Goldfield (Gold Mining) ; S. Heslop, Superintendent, New Beerbhum Coal Company (Coal Mining).

Honorary Treasurer.—T. D. La Touche, Superintendent, Geological Survey of India.

Honorary Secretary.—H. G. Graves, Patents Secretary to Govt. of India.

Members of Council.—G. F. Adams, Inspector of Mines in India; E. C. Agabeg, Chief Mining Engineer, Bird & Co., Sitarampur Division; F. J. Agabeg, General Manager, Apcar & Co.'s Collieries; R. G. M. Bathgate, East India Coal Co.'s Collieries; W. H. Clarke, Agent & Manager, Central Provinces Prospecting Syndicate's Manganese Mines; H. H. Hayden, Superintendent, Geological Survey of India; B. Heaton, Principal, C.E. College, Sibpur; T. H. Holland, Director, Geological Survey of India; T. D. La Touche, Superintendent, Geological Survey of India; C. H. Richards, Superintendent, Coromandel Mine, Kolar Goldfield; Thos. Richards, Superintendent, Nandydroog & Balaghat Mines, Kolar Goldfield; G. F. Scott, Chief Mining Engineer, Bengal Coal Company; J. J. Turnbull, Agent, East India Coal Company; T. H. Ward, E. I. Ry. Collieries; R. Wordsworth, Manager, Warora & Bellarpur Coal Mines, C.P.

Mr. W. Miller, the President-elect, accordingly took the chair which was vacated by Mr. T. H. Holland. A vote of thanks to the retiring President and the members of Council for their services during the past year was proposed and seconded by Mr. F. J. Agabeg and Major F. C. Hughes and was carried unanimously.

In returning thanks on behalf of himself and the Council, Mr. Holland was sure that the succession of the more practical man would conduce to that success which always attended the due commingling of practice and science.

The President then delivered the following address:—

Presidential Address.

BY

William Miller.

GENTLEMEN,

I have, in the first place, to thank the members of our Institute for the honour they have conferred on me in electing me their President for the ensuing year. My every endeavour will be to fulfil the duties of the office to the best of my ability, although I fear I may come short of your expectations. Supported as I feel I shall be by a very able Council, it is certain that nothing will be wanting in their efforts or in mine to promote the objects of the Institute. I have therefore every hope that the work of the Institute will be performed during the current year equally as well as it has been during the previous years of the Institute's existence. Nevertheless it must be understood that the President and the Council cannot do everything to keep and make the Institute as successful as it ought to be without the very active support of the members themselves. It is hoped, therefore, that the members will continue to take a keen interest in all that tends to reach that success, and I would especially point out the great utility of the members preparing papers and reading them at the various meetings, on the numerous subjects that come within the objects of the Institute. I desire particularly to impress this on the younger members, although I trust the older members will also come forward and contribute. To make the Institute a success, it is very necessary that as many members as possible should attend the meetings, prepared

to take part in the discussions, for without discussion the merits of the papers read will, in many cases, not be divulged.

In addressing you to-day as your President, I am merely carrying out the law of precedent which our retiring President, Mr. Holland, was good enough to create, or to quote his own words in his first Presidential Address delivered two years ago: "I am painfully conscious of the circumstance that I am filing a specification which, by the law of precedent, ties my successors to a custom," gently adding, "they may wish to modify or abandon." Standing here before you to-day as your President, I would prefer to accept the latter course, so I hope you will forgive me if I partly adopt the intermediate alternative of modification. I am quite sure you will not expect me to afflict you for an hour or more with a Presidential Address.

It appears to be usual in most Presidential Addresses to Institutes such as ours, to deal in a general way with one or more subjects which may be to the front at the moment and interesting to the members. With your indulgence my text on this occasion will be "Coal Mining in India," which is so very much to the fore in India at present. This subject opens up a wide field, and I can only treat it in a very cursory and general way. My remarks will chiefly apply to Bengal, beyond which my Indian experience of coal-mining does not extend.

In the first place all connected with coal-mining in India must be congratulated upon the present satisfactory condition of the coal trade of the country, and a continuation of the present satisfactory conditions is eminently desirable.

Coal-mining in India, and especially in Bengal during the last 20 years, has increased enormously. Twenty years

ago the output of coal over the whole of India was something like 1½ million tons. The year 1906, the latest figures available, saw the output reach fully 9 million tons, and out of this fully 8½ million tons were raised within the Province of Bengal. It is to be hoped that when the figures for the year 1907, just closed, are available, an output of 10 million tons will be shown. India's yearly production of coal now exceeds any other single British Colony or Possession, and indeed stands next within the British Empire to the Mother Country itself. The Australian Commonwealth and Canada closely follow with about 8½ million tons each for the year 1906.

Now while in my opinion we have no fear of not maintaining our position in the production of the British Empire, yet we are not ambitious enough ever to dream of reaching the production of the Mother Country with its 250 million tons. There are still coalfields in India which shortly must be developed with the extensions of our railway systems. Yet if we are to keep apace with, or ahead of, the other Colonies, especially those two already mentioned, our present methods of working and winning the coal must be improved. One of the greatest factors in this country regulating the output is the labour question. To those outside the trade it may seem ridiculous that there should be a scarcity of coal-cutting labour in a country teeming with people. Yet the fact remains, and for this reason. The people of the country are born cultivators; they are cultivators first, and coal-cutters afterwards. Caste also is a great factor to be reckoned with, and those engaged in mining know how few castes have yet been induced to work in the mines, although every inducement in the shape of good wages and every other comfort possible is offered to them. We have all seen lately the great increase of capital

being invested in coal-mining, especially in Bengal, and new coal companies are springing up like mushrooms. I counted the other day in one of the Indian commercial papers between 80 and 90 limited liability Coal Companies now existing; and there are still rumours of more to come. It is understood to be a fact that one of the undeveloped coalfields may shortly be entered and opened out extensively. With our limited, or at least slowly increasing, labour supply, it is a question how all this increased capital invested in coal-mining is to get its return. Some may say with present ruling prices the return is assured. That may be admitted, but will it last? There is no doubt it will endure for some time. The amount of capital invested in the coal mines of Bengal, taking only the limited liability companies, shows approximately a figure approaching Rs. 500,00,000, including ordinary, preference and debenture capital. Out of this sum the ordinary capital amounts to Rs. 440,00,000. This ordinary capital at the present day is at a very high premium and represents approximately no less a sum than Rs. 2,600,00,000 equal to fully five times the nominal value. To pay a 6 per cent. dividend on this latter sum means an earned profit of Rs. 156,00,000. If the annual output of these limited liability companies be taken at about 8 million tons, leaving a balance to be raised by private concerns, it will be found that to enable a dividend of 6 per cent. per annum on the present-day value of the invested capital to be paid, a clear profit of nearly Rs 2 per ton of coal raised must be earned. With the present-day selling prices of coal, the industry is no doubt in a strong position, and can easily earn that profit even with the present output and present high premium of our Coal Company shares. Yet it can be easily seen that should prices of coal fall, the average dividend of 6 per cent. on

the present high prices of coal shares could not be long maintained unless we can be sure of an ever-increasing demand to cope with the necessary increased output that may be expected. To ensure this we must look to other means of raising our output than the present available labour force. In my opinion the coal-cutting labour force is not at present increasing with the demand for our coal, and to this factor we are partly indebted for the present high ruling prices. If that is admittedly so, then how are we to keep pace with the demand?

The introduction of coal-cutting machinery must be thought of, and already several of our Coal Companies are devoting their attention in this direction. I trust their efforts will meet with the success they deserve. But the introduction of coal-cutting machinery is not the only improvement in our methods which we must look to for the general improvement of the coal-mining industry to increase output and to reduce costs.

There are many other matters which should engage the attention of the colliery manager and mining engineer in this country. During the last 20 years, to which my own experience extends, very considerable improvements have been introduced, largely because deeper mining has become more general, especially in the Ranigunge and Giridih Coalfields, and to a lesser extent in the Jherriah Coalfield. Twenty years ago it was the exception to see a coal-pit fitted with cages; now it is the general rule. The winding and pumping plant was of the most primitive sort, as was also the general fit-up of pithead arrangements. Underground, except where inclines were at work, tubs and tramways were practically absent, and the coal had to be carried long distances underground on the heads of the coolies and native women to the pit bottom. All this has

almost completely changed within the last few years. At many collieries in the Indian Coalfields can be seen winding and pumping plant of the most modern type; well-built chimney stalks are dotted all over the coalfields, and Lancashire boilers provide the necessary steam power. The pit banking arrangements are not yet up to the standard that should be expected, but gradually they are being improved. At many collieries, especially the deeper ones, high level scaffolds with tippler and screening arrangements are in use. At one or two collieries, mechanically driven shaking screens and travelling belts or tables for picking purposes have been introduced. Underground, in the deeper workings, it has been found necessary to introduce haulage machinery. Formerly with shallow sinkings it was generally the rule, when the underground workings advanced too far from the pit bottom, to sink a new pit. Often these shafts were not more than 400 to 500 feet apart. With the deeper workings, the cost of sinking becomes an important consideration, and it is necessary for the mining engineer to place his pits farther apart, and in the most advantageous position in the property or area to be worked, so that they will work and win the greatest area of the available coal. The underground workings, therefore, in many of our collieries extend to very considerable distances from the pit bottom, and the introduction of a haulage system has become a necessity. At present these haulages are principally confined to hauling from the dip workings, and mainly are of the single rope type. The angle of the dip generally lends itself to this system.

In the rise workings the brake wheel has been introduced for lowering the full tubs and raising the empty ones. Both systems are a great saving in labour as well as in cost, but the tail rope and endless rope systems should

be more universally used, especially for hauling along the "levels" which, in some cases, extend to great lengths. Labour, of course, being cheap, has hindered the introduction of such haulages; but the labour saved by the introduction of a haulage could be very advantageously utilised on other work of the colliery.

At several collieries air-compressing plant has been introduced, especially for underground pumping. For that purpose it lends itself better than steam power, which heats the workings and damages the roof. Compressed air has all the advantages of steam while the loss in power in long distance transmission is reduced. Further, it cools and helps to ventilate the underground workings and does no damage to the roof.

The introduction of electricity as the driving power underground, it is pleasant to note, is also receiving attention from some of our coal companies, and doubtless this power, a few years hence, will be more generally used in our coalfields for hauling, pumping, coal-cutting and other purposes.

Another question which requires more attention in our coal mines is the method of ventilation. The universal system at present, with one or two exceptions, is "natural ventilation." No doubt the thick seams worked in the coalfields easily lend themselves to unassisted ventilation, and this is the chief reason why artificial means of ventilation have not been more largely resorted to. In some of our collieries very good results are obtained from natural ventilation, aided of course by the heat from steam pipes in the shafts, and the exhaust steam from pumps in the pit bottoms. Very often, however, full advantage is not taken of the current, and the ventilation allowed to scatter or spill all through the underground workings instead of being

properly conducted by built stoppings and temporary bratticings round the working faces. Now I am glad to say that the question of conducting the ventilation is receiving a good deal more attention than it formerly did. With mines gradually getting deeper and deeper, it is only natural to expect that the chances of meeting with explosive and other obnoxious gases is increasing. Consequently it is very essential that the proper conducting of the ventilation through the mine should have closer attention. The day is fast approaching when mechanical ventilation by exhausting or forcing fans will have to be more universally adopted. Only a few of these fans are at the present day in use in our coalfields.

The mode of working the coal seams in Bengal is chiefly confined to the pillar and stall system, for the simple reason that the seams worked are generally very thick and do not readily lend themselves to any other method. I am aware that in Giridih and Assam the Staffordshire system of working thick seams is being practised—and it is a very good system indeed ; but most commercial concerns are not in a position to adopt this mode of working. When the thinner seams come to be worked, say seams five feet and under in thickness, mining engineers and colliery managers should consider the question of working them on the long-wall method. The labour of course will require to be trained to it, and there may be some difficulty at first ; but by perseverance it can be overcome. Over 20 years ago at Sitarampore a seam about five feet thick was worked on the long-wall system with fair success. I believe also at the present day the Sitarampore Coal Co. are working a five-feet seam successfully on this system at their Nursomuda Colliery. It would be interesting to the members of this Institute if the

manager of the colliery would give us his views on the success of the system, with a comparison of cost and the percentage of the coal obtained compared with working on the pillar and stall system. In former days working by the latter method about 60 to 80 per cent. of the coal was worked out in the galleries. This meant leaving small pillars for the support of the roof. These small pillars had to be left in when the mine was abandoned, necessitating the entire loss of 20 to 40 per cent. of the coal in the seam. Gradually the advantage of leaving larger pillars is beginning to be recognised, but in many cases they are still left too small to be afterwards removed with the least possible minimum of loss.

Unless very large pillars are left in the first working, say pillars containing at least 60 per cent. of the coal in the seam, there must be considerable quantities of the coal sacrificed when removing the pillars. The best authorities now advocate that not more than 20 per cent. of the coal should be removed in the first working, and it has been proved by doing so that a very high percentage of the coal left in is got when removing the pillars. In some cases it has been found in working seams up to seven and eight feet thick that the loss has been less than 5 per cent., but with thicker seams the loss will be correspondingly greater, according to thickness and nature of the roof and floor, etc. The question of leaving very large pillars is one well worth the serious consideration of our colliery managers and mining engineers.

Another subject which I would like to call attention to is the consumption of fuel on the collieries. It is well known that our collieries are very wasteful in that respect. At the present day, with coal prices ranging from Rs. 4 to 7 per ton, this question is a very much more serious one

than it has hitherto been when prices were very much lower.

In the opinion of some, who are in a fair position to judge, coal prices are not likely to rule so low again as they were two or three years ago. In no country in the world was coal sold so cheaply at the pit mouth as in India. Especially was this the case in Bengal, where in many cases steam coal sold at Rs. 1-10 per ton.

In these days of higher prices, there is sufficient inducement to our collieries to make some attempt to adopt some better means of raising and employing steam more economically. The class of labour which is available for firing boilers is certainly a heavy handicap, but there is nothing to hinder the adoption of the best class of boiler available, such as the Lancashire or tubular boiler. In some cases they have already been adopted, but they should be more universally used. Another means of economising, especially in the deeper mines, is the adoption of compound engines, especially for pumping, air-compressing, driving electrical engines and fans, etc. In many circumstances the adoption of new and modern types of machinery and plant is a serious question, but there are many items of detail wherein great saving can be effected even with the present plant, such as the covering, setting and erection of boilers, steam pipes and engine cylinders. There is also the question of the application of central steam condensers with towers for cooling the hot condenser water. This is particularly essential where only hard water containing much solid matter is available for boilers. Such plant prevents or reduces the scale coating which is not only so damaging to boilers but impedes the steam-raising power of the boiler and increases consumption of fuel. If all these things were looked into carefully there is no doubt that the

present wasteful consumption at collieries could be reduced at least 50 per cent. Consumption of fuel at our deeper collieries is becoming a very heavy item, and is well worth the serious consideration of those in charge.

Before closing I would like to revert for a moment to the question of the extension of coal-cutting machinery for the getting of coal. As mentioned above, several Coal Companies are devoting their attention to the introduction of coal-cutting machinery as a means of combating the labour difficulty and increasing the output. There is no doubt a very urgent necessity in our coalfields for the application of machinery not only to hole and shear the coal but also for bringing it down, and, when brought down, for loading it up into the tubs. This latter is a difficulty which will only be found when coal-cutting machinery has been introduced; at least that has been my experience with the few coal-cutting machines which have been at work for the last few years in one of the collieries under my charge. The miner will do the loading, but demands a fabulous price, and will tell you, if you demur, that he is a coal-cutter not a coal-loader. Sufficient coolie and *kamini* labour is not available in the majority of cases for the purpose. In my opinion it will be found necessary, by those who are adopting coal-cutting machinery to apply machinery also for the loading, if coal-cutting by machinery is to be a success. At some collieries in Great Britain, travelling endless bands are used to great advantage to convey the coal from the face to the tub. There are, therefore, great opportunities for our mining engineers to work out this subject and apply these travelling bands with advantage where coal-cutting machinery has been or is being introduced in Indian collieries.

For some years previous to 1901, the Government of

India, urged on no doubt by the home authorities, had been giving coal-mining a considerable amount of attention with a view to legislation for the better and safer working of the mines. When these enquiries were being made, we felt flattered that the Government thought our industry so important as to engage their attention. In the year 1901 the Government's friendly attentions took shape and the Indian Mines Act (VIII of 1901) was passed and made law. The great majority of those engaged in the management of the mines, I think, welcomed that Act as a step in the right direction, and one that would improve the industry in many ways if judiciously and cautiously introduced and enforced. Up to the present time few of us have had any reason to complain of its administration under the past and present able staff of the Mines Department, and I would here just mention we are very pleased to see our new Chief Inspector, Mr. Wilson, with us to-day. I think I can safely assure him that not only the members of this Institute, but the coal-mining industry as a whole, join in extending to him a cordial welcome to India, and wish him every success in his new sphere of labour.

My reason in mentioning the Indian Mines Act to-day is simply to call attention in a few words to one very important matter. Section 20 of that Act gives the Government of India very wide powers in framing general rules.

Most of us are unacquainted with legislation which leaves the general rules of a Mines Act open to alteration, addition or deletion at the will of the Government of the day by merely publishing them in the Indian official gazette for a short period. In the English Mines Regulation Act, I think I am right in saying, the general rules are part and parcel of that Act, and no alterations whatsoever can be made without the consent of the Houses of

Parliament, in fact without an amendment to the Act being passed by both Houses. Here in India it is all vastly different; the Government of the day in a few short months may make drastic alterations in the general rules.

True the alterations require to be published for a certain period and objections may be lodged against them, but how few of us ever see the official gazette of India. It behoves the Indian Mining Association and the representatives of the coal-mining industry on the Mining Board to keep a sharp outlook for any such alterations or additions proposed, and to advise and consult their constituents immediately. I may mention, that some rather important new rules were made but a short time ago, and are now in force, with regard to underground workings approaching railways, including colliery sidings, also the furnishing of certain yearly returns before the 1st of February each year, which are difficult to comply with and ought to have been very fully discussed; but as far as I can learn, very few interested persons outside of the Mining Board heard anything of these new rules until they came into force. Such a thing should never occur, and the utmost publicity should be given any proposed alteration or addition to the general rules under the Act.

Let me now allude for a few moments before finishing to a subject that affects this Institute more than the subject of coal-mining which I have just endeavoured to deal with. It must have been noticed that during last year comparatively few papers have been sent in to be read and discussed. This is not as it should be, as the objects of our Institute cover a wide field of subjects. Let me read to you the second rule which says: "The objects of the Institute shall be the promotion of the study of all branches of mining methods and of mineral occurrences in India with a view to

disseminating the information obtained for facilitating the economic development of the mineral industries in the country."

This rule covers such subjects as the following, all of which apply to India and are fitting subjects for papers from the members of the Institute:—

Geology and mineralogy.
Descriptions of coalfields.
Boring and prospecting for minerals.
Duration of coalfields.
Colliery leases.
Sinking shafts.
Methods of working thick and thin seams.
Ventilation of mines.
Pumping machinery.
Haulage in mines.
Winding arrangements.
Winning and working of mines at great depths.
Application of compressed air and electricity as motive power.
Consumption of fuel at mines.
Coal-getting by machinery.
Faults and other disturbances.
Gases in workings.
Screening, sorting and cleaning of coal and other minerals.
Safety lamps.
General surface arrangements of mines.
Manufacture of coke.
Brickmaking

The foregoing are but a few of the many interesting subjects which can be made the subject of papers by the members. Let them be short or long, all will help to promote the objects of the Institute, as well as being at the

same time interesting and instructive. I trust therefore more of our members in the year we are just entering will devote their attention to bringing forward papers on some of the subjects mentioned above or any others on which they are well qualified to write. To a crowd of members more than 200 in number, I know I do not appeal in vain.

I have only to thank the members again for electing me as President, and I trust that our Institute, so successfully launched two years ago, will go on prospering and continue to do the good and useful work for which it is intended.

Mr. R. P. Ashton felt bound to differ with the sentiments that had been expressed in respect of the mining rules and the action taken thereon by the Mining Board. He promised, however, that an enquiry should be made as to the amount of publication that had taken place, and would endeavour to see that in future news of any interesting matter should be spread more widely.

A vote of thanks to the President for his address was proposed and seconded by Mr. H. G. Graves and Major Hughes and was carried unanimously.

The President then announced that various papers that had been read recently were now open for discussion, and the remainder of the sitting was taken up with—

DISCUSSION ON "FIGHTING A COLLIERY FIRE."

Mr. W. T. Griffiths did not think that the authors of this very interesting paper had produced sufficient evidence to prove their contention that the "loud rumbling accompanied by a violent blast" which occurred one morning during the fight was due to a fall of roof producing an "air blast." More powerful reasons pointed to the

conclusion that it was an explosion of gas. The first evidence given by the authors was that there was no back-lash perceptible. It was easy to shew that, whether it was an air-blast or explosion, there must have been some amount of back-lash. In the first case the fall did not come to the surface, and it must have been of great magnitude to have caused a displacement sufficient to compress the air in the very large area of workings open, each gallery being also of very large dimensions, and then finally to blow off all the scaffolds from the shafts and to make sufficient noise to bring a man out of his bungalow situated 800 yards distant. The cavity remaining in the roof after such a fall had to be filled with air, and hence a certain amount of back-lash must have occurred. In the case of an explosion of gas, the sudden condensation and cooling of the heated gases in the mine caused a back-lash. Further, the mine was not examined after the blast had occurred except in pit No. 22 down to dam H by two explorers on one occasion, and hence evidences of back-lash if any, which are in nearly all cases visible below ground, could not be seen.

The other evidence given that the quantity of air passing through the opening in the dyke on the south side of No. 22 pit was only about 15,000 cubic ft. per minute might be readily accounted for by falls of the sides of pillars and of the roof (which is 12 ft. of superadjacent shale), near the two openings F and G in the other dyke, causing very small air-passages.

The arguments in favour of an explosion were:—

1. The thickness of strata near pit No. 17, where the large fall is supposed to have occurred, was only 77 ft., and although the rainy season has since passed, there were no surface indications of any such fall.

2. A fall of sufficient magnitude to cause such an air-blast with such a small cover, all being sandstone with the exception of 12 ft. of shale immediately above the coal, would have come to the surface.

3. The distinct report heard was a characteristic feature. It disturbed a man in his bungalow 800 yards distant and caused the miners in the adjoining Reliance Co.'s mine to desire to come up the shaft for they heard it in their workings. The report of the Universal Colliery explosion in South Wales was heard at a town three miles distant.

4. The most violent effects of the blast on the surface were apparent at pit No. 4 where the earth filling in the shaft bottom was displaced and the whole of the arched covering of the pit blown up. This would shew that the explosion followed the course of the intake air as is usually the case.

An eye-witness stated:—

"When the blast occurred I was on top of No. 17 pit levelling off the mud on the stopping for closing up the shaft. At 8 A.M. No. 17 pit was downcasting, and as we were building the scaffold and covering it, puffs of hot fumes issued at intervals. At about 11 o'clock we heard a wheezing noise ending in a loud puff which caused us all to run away from the pit top and blew off the whole of the stopping except the rails. At the same time No. 4 pit discharged a cloud of ashes and bricks, the former having been used as filling and the latter forming part of the arched covering of the pit top. No. 17 pit was covered by about 18-inch thickness of sand and mud at the time of the report."

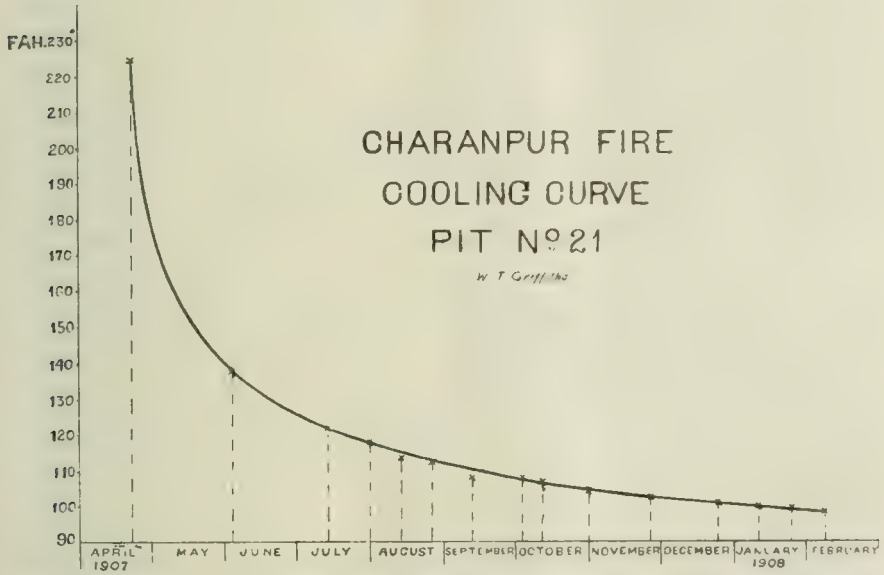
5. The probable condition of affairs in the No. 17 pit area pointed to the conclusion that an explosion occurred.

According to the diary of events, on the morning of

April 2nd, 1907, after an alternating struggle, pit No. 21 was flaming whilst pit No. 17 was smoking slightly, *i.e.*, both were upcasting, and these were the only shafts or outlets open, all the others being shut off. Hence to support the combustion at pit No. 21 a considerable quantity of air must have been leaking through the dams A, B, C, D, and also perhaps a little through the scaffolds, and filling in some of the shafts. A glance at the plan of the mine will show that a dyke exists to the south of a line joining pits Nos. 17 and 21 running in a westerly direction. There were several openings in this dyke near pit No. 17, but there was only one opening through the dyke for a considerable distance along its length towards pit No. 21, and this was near the pit No. 21 end of the dyke. Hence the natural conclusion was that the fire, having originated near pit No. 4, travelled in two distinct and definite directions towards pits Nos. 17 and 21 respectively. This was borne out by the fact that smoke began to issue almost simultaneously from pits Nos. 17, 19, and 21 soon after the fire started. On the morning of April 2nd, the pillars of coal from pit No. 4 to and around pit No. 17 had been burning for some days, and finally when pit No. 21 had gained the mastery, the air to support the combustion there passed along the shortest cut from the leaking dams A, B, C, D, and very little came in the direction of pit No. 17. Owing to the great heat in the pit No. 17 area of fire, a considerable amount of distillation of gases as well as incomplete combustion of coal must have been going on. A very small portion of these gases passed up the shaft whilst the larger portion accumulated in the galleries around the shaft and towards the passages along which air travelled to pit No. 21, the latter pit being to the rise of the above area. Finally when the galvanised

sheets and earth had been put on the scaffold at pit No. 17, these gases must have been drawn into the air-passages and formed an explosive mixture which was ignited at or near pit No. 21.

Since the closing of the fire area outlets the temperature of pit No. 21 had been taken at intervals by Mr. Maltby who used a maximum thermometer which was lowered to the bottom of the shaft and kept there for some time. On being drawn up, the reading and date were recorded.



From the figures kindly furnished by him, the curve shewn in the diagram on this page has been plotted, the abscissæ being time and the ordinates temperature It will be seen that for the first two months the temperature fell very quickly due to the rapid radiation of heat through the strata, but as the temperature approached the normal the rate decreased considerably, and at present the direction of the curve makes a very small angle with the horizontal. The utility of making such records is here

clearly demonstrated for by continuing the curve on the assumption that its form will remain unaltered, we may estimate the time it will take for the temperature of the mine to reach the normal.

Mr. A. Russell wrote that there was not much new to be said on the Charanpur fire as it had been fully discussed already. The cause of the fire was likely to remain a question which would not be answered to the satisfaction of all, but it was not at all unlikely that it might have been a burning torch thrown down on to the stack of sleepers from which the fire spread to the crushed corner or side of a pillar. In his own experience he has had to stop miners or dust-women from carrying torches down inclines or pits in case they would fling them down and set fire to the coal. They have even been known to make fires to warm themselves where the air was cold underground when going to the different dams. As one of the local managers who lent a helping hand on several occasions, during the fire he did not see any accumulations of dust or slack, but saw several galleries with large stacks of round coal which had been cut and stacked ready to be loaded up as soon as a new haulage, which was nearly completed, could be got ready to work. In the galleries from which this coal was cut, where one might have expected slack, there was none. This would tend to show that care was taken to keep the pits free from dust. Another point, which has given rise to different opinions was the blast which lifted the roof off the fan drift, and the covers from the tops of the pits. As regards the fall of roof or the explosion of gases, although he was not there at the time, but from the descriptions of eye-witnesses and other evidence he had always held the opinion that it was an explo-

sion of gases. One of the main reasons given by the authors against this theory was that there was no back-lash, but he thought there must have been, and that it may have been much greater at some other of the openings, for instance through the fan drift, which was much nearer the seat of the fire than at No. 17 pit where the work was going on when the blast took place. Again, even if it was a fall of roof there would be a back-lash of air to fill the space, because it was not a fall to the surface, but probably (if it was a fall) it was only the twelve feet of shale above the coal and over the area of a number of nearly burnt-out pillars. Further, the blast took place when an explosion might be expected when the flames were being stifled, and any inflow of fresh air from any of the temporary stopped openings would cause an explosion and bring down the roof where the pillars were small and partly burned.

With reference to the whirlpool phenomenon he had noted a similar case lately where there are no stoppings or bratticings to guide the air. The air comes down an air-shaft, goes to the dip, splits itself right and left, the left hand portion finds its way along the level to where men are working and heating the air with their lights and the heat from their bodies. The heated air makes its way again to the rise and back along the top levels to the same air-shaft where it fights its way near the roof at the shaft bottom and gets mixed and driven away to the dip again with the fresh air. He had no doubt many similar cases existed where no attempt was made to guide the ventilating current.

The establishing of rescue stations was important and should be supported by the different coal companies. At present when large profits are being made by coal companies most of the appliances, tools and materials mentioned

in the paper might be stocked at large collieries for their own use in case of fire, gas, or water; but it might be expected that these special stocks would be drawn upon if trade again got as bad as it was a few years ago. But the central stations would retain their stocks ready, as well as afford the opportunity of training men in the use of the appliances and in the necessary procedure if fire, gas, or water had to be dealt with.

Mr. T. Chrystle remarked that on looking through this valuable paper he thought a very interesting and important point, and one well worth discussing, was the question of spontaneous heating, and whether it was not possible that the Charanpur Colliery fire originated from spontaneous combustion; and he raised the point in order to help forward the discussion of the paper.

He noted that about the seat of the fire there were several pillars of coal measuring 18 ft. high by 16 ft. wide, 18 ft. by 15 ft. wide, and one pillar only 12 ft. wide, the height of the pillar in this case being 6 ft. more than the width of it; and he could imagine that a pillar 12 ft. wide would easily become fissured; also there was the cleat of the coal and any breaks or slips that might have existed, to be considered. He felt somewhat inclined to think that one or more of the pillars might have become fissured, filled in with fine coal dust, and partly buried up with the slack which he was informed had formerly been used as tram line ballast; and then the addition of the stacks of sleepers which had been placed against the roadside would all aid to heating, and that the fire might possibly have been caused in this way.

He had known of cases where everything had been right at night and a pillar of coal all aglow by next morn-

ing, and the roadways adjacent entirely free from any accumulation of slack or small coal.

One was struck by the rapidity with which this fire travelled, but considering that the coal dust ballast had been loosened up by taking out the rails and sleepers, stacks of creosoted sleepers at intervals along the road, and add to this the coal bursting off the burning pillar sides; also (he understood) about 2 ft. of coal (left as roof) would be cracked down by the intense heat, and so ample burning material would readily be found with a current of air to fan up the fire.

As mentioned in this valuable paper, too much care could not be exercised in laying out underground workings in the most suitable way to cope against fires whether "gob" fires or otherwise.

He had had considerable experience in dealing with underground fires, and had been able to deal with fires in districts laid out on the panel system without interfering with work going on in other parts of the seam. On one occasion a fire broke out in a seam of coal, which seam had been laid out in panels. This fire necessitated the building of stoppings in a level driven through a rib of coal; and in preparing places in which to erect the stoppings the rib was found to be so much fissured and crushed that by the time ground sound enough to build the stoppings against was found, a place had been made 49 ft. at the base and 22½ ft. at the highest point. On account of a large quantity of gas being given off it was found to be a difficult task to finish these stoppings, but the work was completed and the fire effectually dealt with without stopping the work in other parts of the pit; and he was of opinion that but for the division of the workings into panes the whole of the recovery in the seam would have been lost. These

stoppings were built with a good class plastic brick and good and properly mixed mortar; and every brick, when laid, was entirely covered with mortar; and the spaces between the brick walls were filled in with riddled and very fine mine dust obtained from a heap of calcined ironstone. This dust or ash is very heavy, and if put in in small quantities or layers and well rammed, will set very close. In putting in other stoppings he had used sand.

In looking through the list of useful articles to be kept in case of fire, he said he had done some very good work with the little fire "extincteur" and with its aid had been able to dig out material so hot that in one case the pit tubs (wooden) had been set on fire. The "extincteur" is also useful in case of surface fire. Fireproof brattice cloth was preferable; he was once called to a fire and found a large quantity of tarred brattice cloth all ablaze and setting fire to the roof timber.

Iron doors have been found very useful in certain cases, and Sirdars could be instructed as to the closing of these in case of fire, which would help keep such fire in abeyance until European officials arrived on the spot.

Mr. F. J. Agabeg touched on the question of whether the sleepers in the mine, where the fire orginated, were set fire to by spontaneous combustion or by careless handling of lamps by the workers. He gave it as his firm conviction that it was due to an overturned lamp. If it had been spontaneous combustion he was sure there would have been some smell apparent for days before the fire. Also during the many years that he had been working that mine he had never had a case of spontaneous combustion. He thought the rapid spread of the fire was due to the great heat evolved by the burning sleepers.

Mr. T. Chrystle said he did not go into the question as to the strength of the pillars, but raised the point he had done to help to further the discussion, but at the same time considering, with other things, the dimensions of the pillars mentioned in the paper, he thought it not impossible that air might find its way right through a pillar of coal 12 ft. in width.

Mr. G. George remarked on the advisability of getting the opinion of the Society as to the size of the pillars it was advisable to leave, and also on the subject of the effects on the surface in the matter of subsidences.

Mr. G. F. Adams said that in reference to the question which had been raised as to the effect of wide galleries on the spread of the fire, he thought everyone must admit that the greater the gallery space and the smaller the pillar space in a given area of old workings, the quicker a fire would spread if it once broke out, and the more difficult it would be to cope with. Mr. George had drawn attention to this matter, and had very rightly said that managers should seriously consider the distances apart at which they would drive their galleries, thus determining the size of their pillars. It should, however, be pointed out that it was not entirely a question of what size the pillars were when first formed. It was what size they gradually became as the years went on. As everyone knew, pillars had a mysterious tendency to get smaller and smaller, and galleries wider and wider. As long as the pillars were not made large enough to get them systematically, so long would the risk of fire continue. What had been done in the past could not be altered. It was to the future that they must now turn. He would be glad if Mr. Griffiths would state where the gases

which caused the explosion came from, so that they might understand to what gases Mr. Griffiths referred as the cause of the explosion. He thought the discussion on the paper ought not to close without their taking into consideration the suggestions put forth by the authors as to rescue stations. Whether members were in favour of them or not, it would be most desirable that they should record their opinions ; and he would ask those present who were in charge of collieries, and who therefore had an interest at stake, to do so. One thing appeared to him to be worth noting, and that was that it would be no use keeping perishable things such as cement—and a good many other things were perishable in this country—unless arrangements were made whereby they would be frequently changed. The rescue stations might be made depôts where colliery managers could procure such things when required, and in that way a constantly fresh supply could be maintained.

Mr. W. T. Griffiths, in reply to Mr. Adams, said that the gases which caused the explosion were those usually produced by the distillation of the coal (such as those formed in gas-works), and also those produced by incomplete combustion, *viz.*, methane, hydrogen, and carbon mon-oxide. Further, he did not suppose the explosion to be due to a perfect explosive mixture of gases but to an imperfect one. For instance, one may get an explosion with 6, 7, or 8 per cent. of fire-damp and air, or with as much as 12, 13, or 14 per cent., and each explosion would increase in violence as the mixture rose to nearly 10 per cent., and afterwards diminish in its intensity as the mixture was increased up to about 15 per cent., when the explosion would be quite a feeble one. Actually a mixture of fire-damp and air has the maximum explosive force when the proportion

is 9·38 per cent. of the former. An excess of fire-damp acts like an excess of air, and as the percentage is increased above 9·38 per cent., combustion becomes less and less perfect. In the explosion at the Charanpur mine there was, in all probability, an excess of combustible gases.

Mr. W. Miller (President) concisely reviewed the chief points raised in the discussion—(1) as to the cause of the fire; and (2) as to whether there was an explosion or a rock-fall. In his opinion the stack of sleepers was admitted (there may or may not have been dust) to be sufficient to fire the coal. He did not think it was due to spontaneous combustion, of which he had never seen any in any mine working the same seam of coal as at Charanpur with which he had experience, though it had occurred at the pit-heads where there was much small coal stacked. He thought Mr. Agabeg was perfectly correct in believing it to be due to the stack of sleepers having been set on fire by some careless workman. With regard to the air-blast, he thought the arguments against a fall were good. There was only 70 ft. of cover with a band of shaley sandstone of 12 ft. thick above the coal, and this, if a fall had taken place, he thinks would have shown traces at the surface of the ground, as to which he understands there were none. In his opinion the fall of this twelve-foot band was not sufficient to account for the blast that took place and was stated to be strong enough to damage the temporary dams and lift several of the coverings placed over the pit mouths. In view of these facts he believed that Mr. Griffiths was right and that an explosion took place due to the gases generated in the confined space of the closed-up mine.

Commenting on the method of fighting the fire, he paid a tribute to the arrangements made by Mr. Pickering

in building fire-dams on the south side and closing up the tops of the pits, after which everything became perfectly safe.

With regard to what Mr. Adams had proposed about establishing rescue stations, he thought it would undoubtedly be a good thing, and ought to be done. It only required a few mine-managers to lay their heads together to have it carried out, and personally he was willing to assist in any scheme that might be brought forward for the purpose.

Mr. T. Chrystle asked the President if he wished to convey to the meeting that " gob " fires in this particular seam were impossible.

Mr. J. Grundy thought the idea of spontaneous combustion was far-fetched, when men had long been going about and sitting with cans of kerosine oil in the form of lamps where the stack of sleepers is said to have taken fire. He thought the importance of endeavouring to come to some conclusion as to whether it had been an explosion or a rock-fall which caused the air-blast on the 2nd, lay chiefly in the fact that one would then know what to expect in the future when doing similar work, and could be prepared to meet it. He said that it was the impression of those nearest pit 17 at the time (among whom he was) that the blast was not sufficiently strong to have been caused by an explosion. The noise heard at pit 17 he said was principally caused by the rush of air rumbling past the sheet-iron scaffold. Only a little smoke issued from the pit. He therefore supported the fall theory, and it seemed to him that a big fall would have been quite enough to give the impression without any explosion.

Mr. T. Chrystle said he remembered a seam of coal practically free from pyrites, and this seam was worked extensively without any fire troubles. Later on a new recovery was made in the same seam but on the other side of a large fault; pyrites in this new district could be seen embedded in the coal in large lumps; and whilst in the former case no trouble arose from fires, yet in the latter he had to deal with several "gob" fires which broke out. He perhaps ought to mention that more moisture was found in the district where the fires occurred than in the old district, and undoubtedly that would have a lot to do with the goaf heating.

Mr. W. T. Griffiths thought that the question of an underground fire in a mine is of such importance that every possible means should be tried in order to get at the origin so that future precautions may be taken. There was no doubt but that under certain conditions spontaneous combustion may arise, and one very good example came within his own experience. In a mine worked in South Wales the coal often contained lenticular masses of "brasses" near the bottom of the seam, which were picked out at the cleaning belts on the surface and afterwards discharged on to the colliery dump heap. For many months this refuse was dumped on the same site so that some hundreds of tons had accumulated in one heap. Under the action of the weather the lumps began to crumble into fragments and powder, and one day the heap was seen to be on fire. There was no other possible explanation for the origin excepting spontaneons combustion, for the fire commenced well in the middle of the heap. This refuse contained by analysis about 8 per cent of sulphur which was not sufficient to pay for handling and freight, etc., to a chemical

works to be converted into sulphuric acid. The sulphur occurred in the form of pyrites which, under the action of the weather, began to oxidise, thus generating sufficient heat to ignite the mass.

For a long time it has been thought that underground fires due to spontaneous combustion are caused solely by the oxidation of the sulphur in the coal, but recent research tends to show that coal itself in a sufficiently finely divided state, and under certain conditions of dampness and temperature, may oxidise so rapidly as to generate sufficient heat to become ignited.

Now, Bengal coals were, as a rule, singularly low in their sulphur contents, nearly the whole of them containing less than0.7 per cent. and up to the present the underground fires that have occurred appear to have been chiefly confined to the seams in the Raniganj Series. This, of course, is partly due to the fact that these coals have been worked for a much longer period of time , and in the earlier days of coal-working the methods and discipline with reference to underground lighting were no doubt of an inferior order. But the fires considered all together seem to be more than accidental, and it would appear as if the cause of origin must be sought in some particular properties, structure, or composition of these coals.

Mr. P. J. Brühl said that as far as the subject of spontaneous combustion was concerned, a great deal depended on what is known as the temperature of ignition, and the time-rate at which oxidation takes place. The latter increases very rapidly with the temperature. In many chemical reactions of the kind considered, such as the oxidation of iron, a few degrees rise in temperature increased the time-rate of the chemical reaction. For instance, the time-

rate at a temperature of 90° might be several hundred times as great as that at 60°. The time-rate would also be influenced by the amount of surface presented to the air ; for instance it is known that it was much greater if any substance is in the powdered condition.

In support of this he mentioned a stack of Assam coal at Sibpur which he remembered a number of years ago when he was specially interested in coal analysis. Most of this was in the form of exceedingly fine dust and it gave rise to spontaneous combustion when used on board-ship. But it was important to remember that Assam coal contained about 3 per cent. sulphur, and was much richer in it than Bengal coal. He therefore thought there was less danger in the case of the latter than in that of the former as regards spontaneous combustion.

Mr. W. Miller (President), in ~~closing~~ Postponing the discussion on "Fighting a Colliery Fire," expressed the hope that some member would take up this important side issue which had been raised, namely, spontaneous combustion, and read a paper before the Society on it before long.

DISCUSSION ON MR. ADAMSON'S PAPER ON THE CHELSEA ELECTRIC GENERATING PLANT.

The author remarked that since writing this paper he had been informed by the manufacturers of the generator sets that the coal consumption at Chelsea is about 4 lbs. per kilowatt hour. This would no doubt be considerably reduced if the plant worked up to its full power throughout the twenty-four hours. Although for three or four hours a day it works at full power, taking it over the twenty-four hours, the plant was not (February, 1907, when he saw it) giving out 50 per cent. of its capacity.

The following errata in the printed copies of his paper in the "Transactions," Vol. II, should be corrected :—

Page 163, line 18, *for* 333 cyles per second *read* 33·3 cycles per second.

Page 167, line 26, *delete* chimneys.

Mr. W. T. Griffiths thought that they should be very grateful for the excellent description of one of the largest generating stations installed in the United Kingdom. It gave them an idea of the magnitude of the application of electricity at the present day, and there was no doubt that this tremendous energy would become more and more necessary in industrial life.

With reference to the subject of "frequency," the corrected figure of 33·3 was normal. There was a difficulty in getting motors to work in unison with a system of a very high frequency. The result was that in an alternating generating plant for power purposes the frequency was as a rule below 50 (generally not more than 25) for the simple reason that it was thus much more easy to get the motors to start in unison with the generating plant The same was true also for generating plant for lighting purposes, only of course we got a higher frequency there—anything up to 100. He commented on the totally different idea given us by the general arrangement of the power plant from that to which they had been accustomed, the boilers being overhead and the engines underneath.

Mr. Haggie remarked that Chelsea station was only one out of eight others in London, that in future they would standardise periodicity, 25 being preferable.

The discussion was then postponed till next meeting, as was also that on the papers on "Blasting powder and

premature explosions," by Mr. J. Grundy; and on "Sampling of ores and bullion," by Major F. C. Hughes.

ELECTRIC MACHINERY.

Mr. R. H. Haggie showed a number of lantern slides of various classes of electric machinery, more especially of those types suitable for colliery purposes, both above and below ground. The views included generators or dynamos for continuous, alternating and multiphase currents with the steam plant for driving them; sinking and other pumps; coal-cutting machinery; winding and hoisting plant; endless rope and other haulage plant, etc., etc. A paper on this subject was promised.

THE ANNUAL DINNER.

The Annual Dinner of the Institute took place at the Volunteer Headquarters, Calcutta, at eight o'clock. The chair was occupied by the President, Mr. W. Miller, who was supported by His Honor Sir Andrew Fraser, Lieutenant-Governor of Bengal, the Hon. Mr. J. F. Finlay, the Hon. Mr. A. A. Apcar, Sir E. Cable, Mr. Hobhouse, M.P., Mr. W. L. Harvey, Mr. T. H. Holland, F.R.S., ex-president, and the following members and their guests:—

Messrs. C. H. A. Armstrong, C. T. Ambler and his two guests, E. C. Agabeg, F. J. Agabeg, G. F. Adams, Thos. Adamson, P. Brühl, Harry Brown, M. Jacomb-Wood, D. Blair, R. J. Browne and his guest, W. R. Criper, Thos. Chrystle, S. T. Creet and his guest, Geo. Dixon, G. M. Darby's guest, H. G. Fleury, W. Forster, G. George and his guest, W. T. Griffiths, J. Grundy, H. G. Graves, S. Heslop, B. Heaton, R. G. Higby, F. C. Hughes, W. A.

Ironside, L. A. Jacobs, C. E. Low, H. H. Macleod and his two guests, J. Mackintosh, F. B. Maltby, T. Morrison, H. C. Martin and his guest, C. H. McCale and his guest, W. McFarlane and his guest, C. S. Middlemiss, Geo. Miller, W. Miller and his two guests, H. C. McNeill, F. T. Marley, C. Nairne, F. Owen, C. L. Phillipps and his guest, E. M. Patterson, E. H. Roberton, A. T. Rose and his guest, A. Russell, H. J. Simpson's two guests, H. L. Swindon, Chas. E. Simmonds and his guest, G. F. Scott, J. J. Turnbull's three guests, A. S. Thomson, H. C. Veasey, A. Whyte and his four guests, D. A. Whyte, J. R. R. Wilson.

After the toast of the King-Emperor had been proposed from the chair and duly honoured, His Honor Sir Andrew Fraser proposed the toast of the evening in the following words :—

"Mr. Chairman and Gentlemen,

"I rise to propose the toast of 'The Mineral Industries of India.' I must begin by saying how great a pleasure it is to me to be here this evening. I have a deep interest in the Mining and Geological Institute of India. It is not precisely a paternal interest, it is rather the interest of one of its earliest friends; for among the most pleasant reminiscences of my work in this country I must place the meeting that we had at Asansol just two years ago when this Institute was inaugurated. I shall always remember the heartiness of the welcome which I received, the inspiring and illuminating addresses to which I listened, and the not less stimulating banquet in the evening. I found myself surrounded by scientific men and practical workers full of eager enthusiasm in the cause. It is a pleasure to me on that account, if on no other, to be present on this occasion. It is also a pleasure to me, because I feel that I may with-

out undue presumption conclude, that the invitation to be here, and propose a toast which it is my honour and privilege now to propose, has been prompted by the belief which you entertain of the interest that I take in the great cause to which you are devoted.

" My interest in the Mining and Geological Institute is elevated by the great respect which its Constitution commands. It includes amongst its members two great classes working together with one object. The one class comprises those who are concerned in geological research; and the other class comprises those who are directly concerned in mineral Industries. The former class includes those directly engaged in research, such as our friends of the Geological Survey, and also those who are engaged in teaching science, in communicating to the rising generation the results of research, and fitting many of them (as we hope) to contribute in the future to the efficiency of that research and of the work generally. The second class comprises amongst its members both those who are directly engaged in working in mines or amongst minerals, and those who are engaged in the very important work of inspection. And both of these great classes comprises officials and non-officials. We have thus brought together in one institution scientific men engaged in research and teaching, practical workers in connection with the mineral industries, officers of Government and non-officials, all labouring together in the same great cause. This is a state of things which it is pleasant to see, and on which we may well congratulate ourselves.

" This union and co-operation of persons and classes not ordinarily regarded as working together, reminds one of an old precept of a venerable law-giver which we can afford to forget. It runs thus : ' Thou shalt not plough with an ox

and an ass together.' Do not misunderstand this precept. Its proper application does not make any demand on your postprandial brains to decide which of the co-operating classes may best be represented by the ox, and which by the ass. It does not even of necessity demand the condemnation of the ass as an inferior worker. We know something of how a good pair of bullocks can draw a very straight furrow; but we do not know much by experience of asses as agricultural labourers. I have indeed considered it expedient on occasion to make a study of asses. It is useful in many ways. It may assist a humble and irretrospective man in correcting certain tendencies or characteristics, or it may assist a man to judge more charitably and therefore more justly of others. It may teach him other valuable lessons. Scientific men tell us that the obstinacy and the stupidity of the ass, and his physical defects are due largely to neglect and ill-treatment, and to the want of any wise and systematic attempt to improve him. This itself is a lesson worth remembering. As to ploughing, Darwin, who is surely an authority on the animal kingdom, tells us that in Syria there are four breeds of asses: one of an easy and agreeable gait ridden by ladies, another of greater energy ridden by men, a third of stouter build for ploughing and similar purposes, and a fourth the large showy Damascus ass. Apparently, therefore, asses when cared for can do more than we think, and can even draw a straight furrow.

"Yet the injunction is, 'Thou shalt not plough with an ox and an ass together.' The meaning is, as it seems to me, that those who are associated in work must be animated by common impulses and motives. They must be willing to work under one yoke. There must be no friction. There must be the possibility of and capacity for

efficient and cordial co-operation. I find this ideal realised in this Institute; and it is therefore that I have a great respect for it and a belief in its future. It encourages, it embodies it illustrates the co-operation that ought to exist between scientific and practical men, between teachers and captains of industry, between officials and non-officials, in the carrying out of the great work in which we are associated. All these different classes are or ought to be animated by enthusiasm for the same cause; and they are or ought to be willing and able efficiently and cordially to co-operate in advance in that cause.

"It cannot be denied that there are signs of many branches of industry which indicate the beginning, and give great hope of the development, of a great industrial revival in India; and the tremendous importance of this to the future history of the country cannot be estimated. There is no doubt that in the recent economic history of India there have been features which must cause grave concern. Economic changes, which in other countries have taken place more slowly, have occurred here with the suddenness of a revolution; and the result has been great hardship and distress to many sections of the community. The first or most marked result of the rapid development of communications, for example, has been the increase in the price of food all over the interior; and imports produced by the more efficient labour of the West have superseded many indigenous industries. In these and many similar instances, changes which might well have been regarded as blessings have been a source of distress to many classes of the community. The urgent necessity of the case is to endeavour to prevent this evil from being of a permanent character; and the minds of all are turned in this connection to industrial revival.

"One sees this not only in vague talk about swadeshi, not only even in the real effort that is being made to work out schemes of technical and industrial education, but also in the marked progress which recent years have shown. To my mind we have a most important and instructive illustration of the character and the real strength of that progress in the Tata Institute, founded by a munificent and level-headed patriot, and in the association of his name with the great iron enterprise which has been inaugurated simultaneously with Indian capital and established, I am glad to say, in this province. I was deeply interested also in a conversation which I recently had with Mr. Thackersay, of Bombay, regarding the great increase of industrial activity there, and the large amount of local capital which has quite recently been devoted to the industrial development of that Presidency. There has also recently been great progress in certain industries in Bengal. I especially congratulate you very heartily on the greatly increased activity in mineral industry both in respect of production and of prospecting. In this we find employment for thousands who are demanding labour; we find means of utilising the mineral wealth of the country; and we see a hope of giving to India even a higher industrial position than that which she formerly occupied in comparison with other nations, by some of which she has more lately been outstripped. We hope to see India, with her own industries, working up and using her own produce, and supplying for herself what has hitherto been largely supplied by the more efficient production of the West. We should all of us like to have our part in achieving this great object.

"For this we require co-operation. We require more information, more enterprise, more devotion of Indian capital to Indian industries, a development of industrial

taste and pride in industrial superiority amongst our people, and better means of technical and industrial education. Government can assist in this. It already assists. It provides officers employed in geological and industrial research. It provides teachers employed in technical instruction. It provides scholarships to send young men abroad for the acquisition of technical knowledge. It can assist in many other ways. If Government is not doing all that it can or is making mistakes in what it does, then let those other classes who are deeply interested in this problem assist the Government with their friendly advice and cordial encouragement; for surely it cannot be denied that Government has a common interest with them in the matter. It is not on Government alone that the responsibility rests. It rests on all those who are in any way connected with industrial work; and it rests also on all those who are in any way interested in the welfare of the country. Government requires to be stimulated; capitalists and workers in this country themselves require to be stimulated; and the people of the country require to have their attention drawn in the right direction. I hope that in this Institute we have a means of securing the mutual encouragement and co-operation of Government and of all classes of the community. Situated as I am, what presses on me most of all is a desire to secure co-operation between Government and those engaged in industrial work; and the first step towards that co-operation is that you should be willing to give us your friendly advice in the matter. If in anything you think you can suggest to us improvements in our methods, lay your suggestions before the officers who are responsible for this work, and let them be discussed in a friendly and cordial manner. Carping criticisms of the Government cannot do much good, for this reason amongst

others that we are far too hard worked to be able to read all that is said in the public press or to engage in controversy ; and many a valuable suggestion may escape notice, merely because it is like a needle in a hay-stack. But if any man or any body of men engaged in industrial work has any carefully considered suggestion to make, I guarantee that, if it is brought courteously before the officers of Government who are engaged in the work, it will receive careful and friendly consideration. I have certain proposals in connection with the new and improved Engineering College, the object of which proposal is to secure more effectively and more constantly the advice and assistance of practical men in the administration of the college. I need not, however, mention these proposals now. What I desire tonight is only to emphasise the necessity for friendly relations between the Government and the industrial community.

"It is with a feeling of personal interest in the matter, that I cordially propose this toast : 'The Mineral Industries of India.'"

Mr. H. H. McLeod replied as follows:—

I am charged with the pleasant if somewhat onerous task of replying to the toast so suitably proposed by His Honor Sir Andrew Fraser. So comprehensive a subject as "The Mineral Industries of India" requires a wider knowledge than I can lay claim to, and it is possible that some of our Mysore friends are longing to dilate on the claims of gold. Although we may not concur in the dictum of Ruskin that gold will never fulfil its proper function until it is used to pave the streets with, it will generally be conceded that coal occupies the premier position in the economy of nature. Our Mysore friends, however, may be comforted by the reflection that of late coal and gold have been quite closely associated. Among the many new coal concerns recently floated there is a growing conviction that several have been promoted with the object of extracting, not coal, but gold from the pockets of confiding shareholders.

When I last had the pleasure of replying to this toast some two

years ago, the coal-mining industry was by no means so prosperous as it is to-day. In fact we had just passed through a period of acute depression. I am not far wrong when I say that the turning point was reached at a date nearly coincident with our first meeting—a happy augury, and one with which His Honor, Sir Andrew Fraser, was very closely associated. I say with all confidence, and in saying so I reciprocate the sentiments expressed by His Honor, that if our annual gathering had no other object than that of strengthening the bond of sympathy between the Government and our respective industries, it would be amply justified on this ground alone.

Now a few words with regard to the present position of the coal industry. The total output of coal for the whole of India during 1906 exceeded nine million tons, of which Bengal contributed 8,617,000 tons—an increase of nearly one-and-a-half million tons on the previous year. These figures are very satisfactory as the average annual increase for the past eight years was only some half a million tons. We have now, however, reached a point where the consumption has outstripped the production, and the resulting comparatively high prices have given rise to a coal boom unprecedented in its intensity and of which I confess my inability to forecast the end.

Mr. Pickering, in his annual report, throws out the suggestion that an improvement in transit facilities might do much to relieve the pressure and so bring prices down to a healthier level. From the prosperous look on your faces this evening, I gather that you do not consider present prices at all unhealthy. It *is* right, however, that we should remember that there *is* a danger point, and our obvious policy is to concentrate our energies in order to overcome the difficulties confronting us. To open out an unlimited number of new collieries with the foreknowledge that they are to be served by the existing labour force and the existing transit facilities is no solution of the problem. It is merely an aggravation of it. From His Honor's sympathetic speech we may take it that the transit problem will be strenuously attacked by Government, but it rests with ourselves to find a solution of the Labour difficulty. I am still strongly of opinion that a partial solution lies in the direction of mechanical coal-cutting plant, and it is encouraging to see so many colliery engineers now directing their attention more particularly to this proposition.

Then again electric power stations are urgently wanted in the

colliery districts, for in its great flexibility electricity possesses a quality which renders it specially adaptable for colliery work, and it is the only power which can be transmitted over any distance with economy and efficiency. I lay some stress on this point as I understand that the colliery electrification scheme is indefinitely hung up owing to restrictions imposed by Government.

It only remains for me to thank His Honor very warmly for the good wishes he has expressed on behalf of the mineral industries of India, and yourselves, gentlemen, for your very cordial reception of the toast.

Mr. S. Heslop proposed the toast of the guests, saying: "Without guests, such a function as this would lose much of its sociability and charm at any time; but it is more specially a pleasure to have with us guests who we know are deeply interested in our Society, and the great and flourishing industry it represents—the mining industry of India. We all well know the keen interest His Honor Sir Andrew Fraser, who is with us to-night, takes in our Institute, the leading part he took in its inauguration two years ago, and the encouraging words he then spoke to us. The good wishes His Honor then expressed have been more than realized, for the Mining and Geological Institute of India has grown and prospered even beyond our most sanguine expectations; and we feel sure it will continue to grow and prosper in the future, as it has done in the earlier days of its existence, and that it will, like the brook, go on for ever. Among our distinguished guests is Mr. Hobhouse, M.P., President of the Decentralization Commission, and I have very much pleasure in coupling his name with the toast."

Mr. Hobhouse replied in suitable terms and remarked upon the trade of India, expressing views upon the export of coal and minerals which did not meet with favour from Mr. Holland, who proposed the toast of the Chair.

Elementary Theory of Cylindrical Dams to Resist Fluid Pressure in Mines.

BY

W. T. Griffiths, A.R.S.M., F.G.S.

Let Fig. I represent the plan of a dam. The pressure on it is transmitted to the sides of the gallery in which two recesses have been cut along axial planes to form abutments. It is assumed that the pressure, which is supposed to be uniform over the surface of the dam, is supported entirely by the two abutments. The weight of the dam is also neglected. Hence we have under these conditions three resultant forces, *viz.*: the total pressure on the dam and the two equal reactions at the abutments.

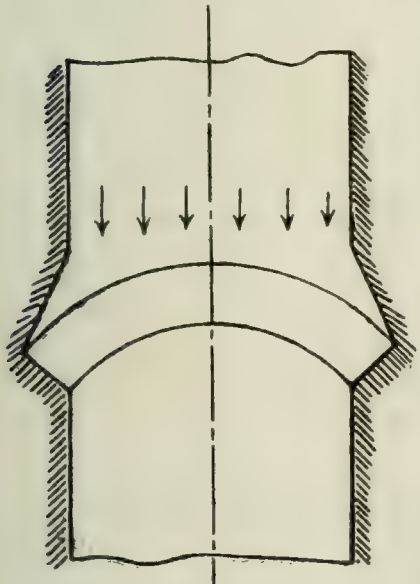


Fig I

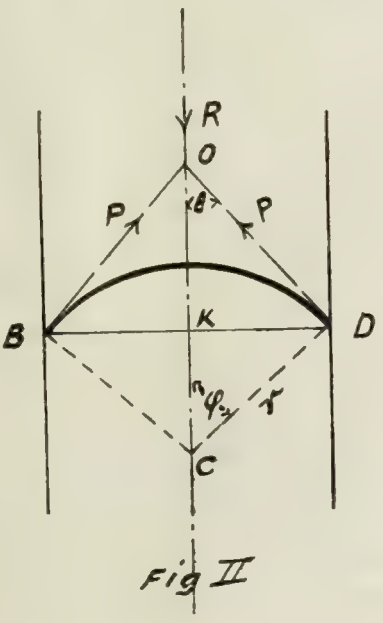


Fig II

Let Fig. II represent a line diagram of the dam together with the forces acting on it, C being the centre of the curve and CO the centre line of the gallery; R represents the total pressure and P one of the equal reactions at right angles to the abutment. Then for equilibrium it is necessary that:—

$$2\ P\cos\theta = R$$

$$i.e.,\quad 2\ P\sin\phi = R$$

$$\therefore\quad P = \frac{R}{2\sin\phi} \ldots\ldots\ldots (i).$$

This equation informs us that when the angle ϕ is diminished (*i.e.*, the radius of the circle is increased), and the total pressure R remains fixed, the reaction P increases. In other words, the flatter the arc, the greater the pressure on the abutments.

Again $KD = r\sin\phi$

and $\therefore\quad BD = 2\ r\sin\phi \ldots\ldots\ldots\ldots (ii).$

substituting in (i) we have:-

$$P = \frac{R\ r}{BD} \ldots\ldots\ldots\ldots\ldots (iii).$$

Let w be the pressure in pounds per square foot and h the height of the dam.

Then $$h.\ BD.\ w = R.$$

substituting in (iii) we get:—

$$P = h.\ r.\ w \ldots\ldots\ldots\ldots\ldots (iv).$$

Put into words (iv) gives the following rule:—

"The total pressure on each abutment for each foot in height of a dam is equal to the fluid pressure in pounds per square foot multiplied by the radius of the dam in feet."

We will now consider an example of a dam to withstand a pressure due to a head of 180 feet of water, the greatest radius being 12 feet. What should the thickness be ?

A head of 180 ft. of water = pressure of $180 \times 62{\cdot}5$ lbs. per sq. ft. Hence the pressure on one abutment per foot in height is equal to $180 \times 62{\cdot}5 \times 12$ pounds..... (a).

The ultimate resistance to crushing of a first-class kiln burnt Indian brick is about 140 tons per square foot. In Dibdin's "Lime, Mortar, and Cement" it is stated as the result of numerous experiments, using cement mortar consisting of an intimate mixture of one part cement with four parts of washed river sand, that the resistance of brickwork to crushing varies from one-half to one-fifth the crushing strength of the brick For bricks of the above strength the proportion is about one-third. Hence we may assume that first-class Indian brickwork with cement mortar of the above mixture would crush at a pressure of $\frac{140}{3}$ tons per sq. ft.

Consider a section of the abutment one foot in height and of a thickness equal to that of the dam, say, t feet. The resistance of the brickwork to crushing is $\frac{140}{3} \times 2240 \times t$ pounds. Equating this to the crushing force (a) and using a factor of safety of 4 we have :—

$$\frac{140}{3} \times 2240 \times t = 180 \times 62{\cdot}5 \times 12 \times 4.$$

$$\therefore\ t = 5{\cdot}2 \text{ nearly.}$$

Hence the thickness of the dam should be 5·2 feet.

It will be observed that the above theory does not take into account any stresses causing bending. It is assumed that the rise of the arch of the dam is sufficient to cause the bricks to crush at the abutments before any bending strain can become appreciable. This naturally leads to the

question as to what is the limit of rise when the curve becomes very flat. If we consider a linear dam, *i.e.*, one built in a straight line across the gallery, and make the assumptions used in the theory that the total pressure supposed uniform over the surface is taken up by the two abutments and neglecting the weight of the dam, then it can be treated as a beam with a uniformly distributed load over its surface and supported at the ends. Such a dam would resist but a small head of water and would fail by fracture in the centre due to bending as shewn in Fig. III; and, as we

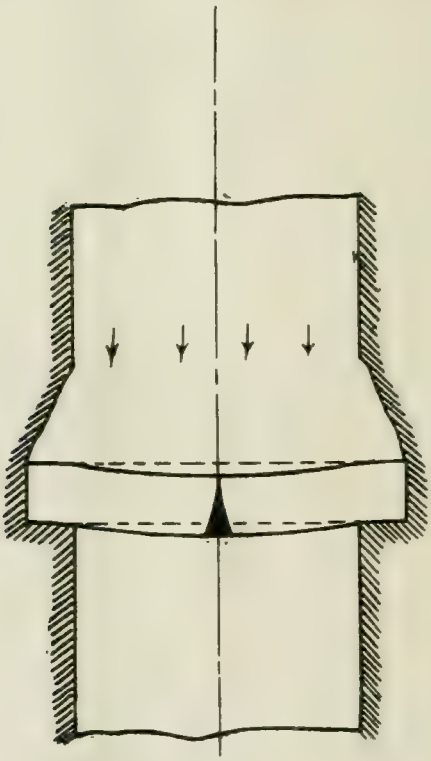


Fig III

know, the resistance of masonry to a bending action is very small compared with its resistance to crushing. In the case of a flat curve we will suppose that the effect of the pressure on the dam is to cause it to become more flat and finally straight. So if we find the amount of linear contraction of the masonry when compressed up to its crushing point, and after using a factor of safety, subtract the quantity so obtained from the original length of the arc, the result should be equal to the length of the chord, *i.e.*, the dam would have become a linear one at its point of crushing ; and this would give us the limit. The contraction is d say, and the factor of safety f, the length of the chord $2a$, the chord of half the arc b, the length of the arc l, and x the minimum rise.

$$\text{Then } l - fd = 2a \quad \ldots\ldots\ldots\ldots (i).$$

Also Huygen's approximation for the length of a circular arc is $\frac{8b-2a}{3}$ . . . . . (*ii*).

Substituting we get $\frac{8b-2a}{3} - fd = 2a$

$$8b - 3fd = 8a$$

$$fd = \tfrac{8}{3}(b-a) \quad \ldots\ldots (iii).$$

$$\text{Also } x^2 + a^2 = b^2 \quad \ldots\ldots\ldots\ldots\ldots (iv).$$

$$\text{So } fd = \tfrac{8}{3}\left(\sqrt{x^2+a^2} - a\right)$$

$$\tfrac{3}{8} fd + a = \sqrt{x^2+a^2}$$

$$\text{Squaring } \left(\tfrac{3}{8} fd\right)^2 + \tfrac{3}{4} fda = x^2$$

$$x = \tfrac{1}{8}\sqrt{3fd\,(3fd+16a)} \quad \ldots\ldots (v).$$

Let us next consider the application of this result in the case of a dam which is 10 ft. wide, and let f be equal to 4. Professor Everett, of the Sibpur Civil Engineering College, informs me that the type of brick-work in the

example given above may be expected to shorten about $\frac{1}{1000}$ of its length before giving way, but half or double of this is not unlikely or even beyond these limits. We will therefore take d to be $\frac{1}{500}$ of the length of the dam, *i.e.*, $\frac{1}{50}$ of a ft.

$$\text{Hence } x = \tfrac{1}{8}\sqrt{3 \times 4 \times \tfrac{1}{50}\,(3 \times 4 \times \tfrac{1}{50} + 16 \times 5)}$$
$$= \cdot 55 \text{ ft.}$$

So the rise of the arch of the dam should be at least 6·6 inches.

In designing a cylindrical dam to be built in any particular gallery, it is necessary that :—

(i) The sides are of greater crushing strength than the brickwork.

(ii) The radii are fixed so as to give sufficient rise to the arch.

(iii) The thickness is sufficient.

(iv) The dam is made watertight.

(v) In addition to the above considerations it will also be necessary to take into account the cleavage of the strata.

The Kodarma Mica Mines and Mining.

BY

Archibald A. C. Dickson.

The mineralogy and geology of mica in India has already been very fully dealt with by Mr. T. H. Holland in his Memoir entitled "Mica Deposits of India." This paper is intended to supplement the information given therein and to describe more particularly the deposits at Kodarma and the problems of working there and disposing of the produce. At the same time some general remarks are offered on the trade in mica. The subjects are treated under the following heads:—

Geology of the deposits.
Mining.
Milling and uses of mica.
Economics.
Cause of failure in working mica on scientific basis.
Classing, gauging and value of mica.
Conclusion.

GEOLOGY.

Kodarma is 1,250 ft. above sea level, Lat. 24° 31′, Long. 85° 38′. It is situated in the Hazaribagh District, four miles north-east of the railway station bearing its name, on the grand chord line of the East Indian Railway.

The chief mica found in these mines is muscovite, which is a common constituent of granite, but the large-sized crystals are confined to the pegmatite which occurs in veins more or less of a lenticular arrangement, interposed

between the layers of mica schist, which forms the country. Though these pegmatite veins usually have the same dip and strike as the country, they are sometimes found cutting across the schist and breaking from one to the other. In all probability this irregularity in the vein is due to earth movement after the original crystallization of the vein material. The veins often exhibit a banded structure, and differ from the true fissure vein in the absence of evidence of extensive faulting, and they conform with the foliation of the enclosing rock They differ from contact or bedded deposits in the irregularity of the ore masses. The breadth of the outcrop ranges from 5ft. up to 300ft. or more, but is not continuous along the surface. As a matter of fact, the outcrops nip for long distances and then may reappear as a mere quartz boulder on the line of strike or a little to one side of this line. The veins have a width of 10 to 150 ft. or more and the lodes run one behind the other in close proximity; in fact it is very common to find three or four of these lodes one behind the other as shewn in Fig. 3.

In Fig. 1 will be seen an occurrence which is very common in the district. The hanging and foot walls consist of mica schist, next to the hanging wall comes a concentrated mass of densely packed books of mica, of small diameter, which are twisted and bent owing to the crowding of the books among themselves. This is locally known as *lapat* by the natives. Then comes the pegmatite proper, with a massive quartz core. Fig. 2 is much the same with the exception of the *lapat* and the addition of a "horse" of schist.

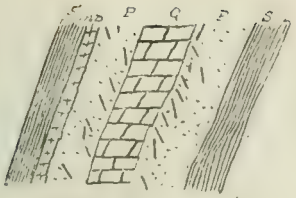


Fig1

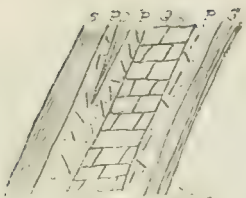


Fig2

BOOYA HILL

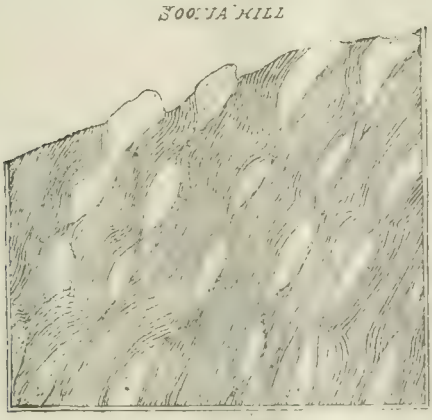


Fig3

SCHIST PEGMATITE

TRANSVERSE SECTION

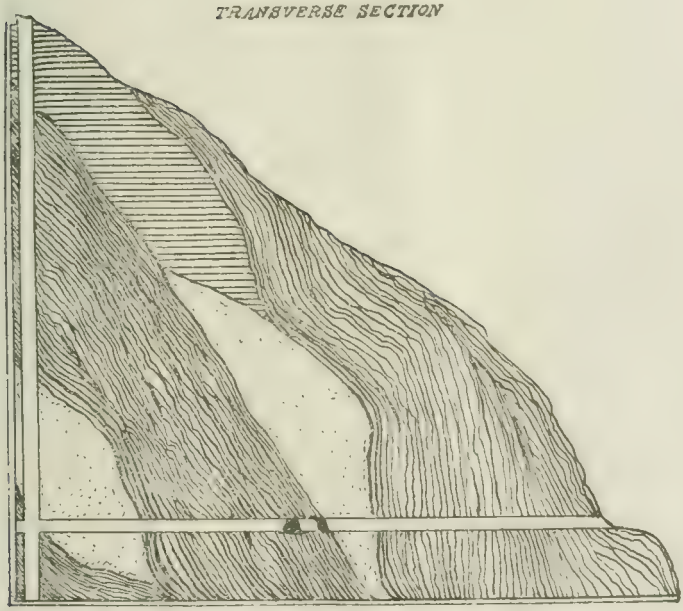


Fig4

PEGMATITE SCHIST OLD WORKINGS

The pegmatite veins, worked under the direction of the writer, have a general dip of 75° and strike W.-N.-W., E.-S.-E. The crystals of mica are not distributed evenly through the lode, nor is the distribution quite irregular. The books or crystals of mica have a tendency to collect in bunches or rows of crystals, and are, therefore, found arranged along one or the other of the walls, often on both walls and sometimes in bunches in the centre of the vein forming chutes at intervals, and not infrequently in pockets at the sides of the lode. The mica extracted from the zone atmospheric influence, which varies from a depth of 12 ft. to 55 ft., is usually poor in quality, but after this the quality of the mica improves.

Erosion has laid the pegmatite bare and the soil formed by the disintegration of the pegmatite, or more correctly of the quartz and feldspar, has imbedded the large crystals of mica which have come away from their matrix. Further erosion and sand blown from the river beds has covered this layer of newly-formed soil containing quartz, feldspar and large crystals of mica, hence the numerous surface deposits. In some instances the large crystals of mica are found in the friable silicious sand (kankri), stained red by the sesquioxide of iron liberated from the vein stone by the disintegration, and in other cases the large crystals of mica are found in the decomposed feldspar (Jogni mati) which seems to form layers one over the other at intervals in this friable silicious sand.

It seems as though the quartz and feldspar form a matrix for the mica, as it is found that the books leave striated marks on the quartz, and the feldspar acts as a support to keep the mica in its place. The feldspar is removed first in extraction, when the book of mica drops away from its place in the quartz. Therefore, it is con-

cluded that the mica crystallized first or together with the feldspar and quartz solidified last. It must further be pointed out that the massive feldspar often contains large crystals of mica, but nearly always within a distance of 20 ft. of the massive quartz; further away the crystals are usually small.

There are chutes or bunches which have about the same level in parallel lodes, and if the miner takes careful note of this, he may be able to obtain average results fairly well from the various lodes. The working of one is the key to all others parallel to it.

According to Mr. Fritz Cirkel there are mica veins in Quebec being worked at depths of 900 to 1,100 feet.

MINING.

Mica being of a different nature to other ore, has to be mined differently, and there has been a great deal of talk about the wasteful method of mining. The writer agrees with the miner, who believes in following the ore to a depth of 100 ft. measured along the dip, before starting any dead work, as by the time he gets to 100 ft., he is sure whether it will pay the cost of driving cross cut tunnels or sinking shafts, *i.e.*, whether he will get sufficient mica, when all the stopes are being worked, to cover the loss incurred by the dead work and leave a fair margin of profit. Of course, if the Company have a core drill to remove a core of 15 inches in diameter, they can start prospecting at once. The drill is a most essential machine for all mica mining operations, as it is the most rapid and economic method of prospecting and of testing the continuance of the vein at the lowest possible cost. It indicates to the intelligent prospector the exact depth of the ore body, the

thickness, regularity and other characteristics of the veins, and the nature of material to be cut through before the vein is reached.

There is a great tendency to guddling, *i.e.*, the removal of sufficient rock, so as to follow the mica from book to book by running the openings zig-zag in a crude fashion. It enables the miners to extract the greatest quantity of mica at the least expense, but only for a few days, after which the mine is shut down or the miner tells the same old story "struck a fault" (*par purgia*) when it is really want of ventilation and working room. This is the tendency of native sirdars when left to themselves; the consequences are that there are hundreds of good deposits which were opened in the old days in this way and subsequently filled with rubbish. The sooner this is put a stop to the better.

The writer has issued standing orders that the ore is to be followed till it reaches a depth of 100 ft. or more before any alterations are made. Then the dip and strike of the lode and other necessary notes are made, after which the plan of proposed method of work is drawn, posted and the usual mining on scientific basis modified to suit the case of occurrence is pursued.

Blasting gelatine and dynamite are the only explosives used.

The introduction of power drills, pumps, etc., will certainly lower the working expenses, a great consideration at present, as there is not much of a demand for very large-sized crystals, owing to the fact that micanite is better adapted for use and is much cheaper. Now the miner has to remove the greatest amount of pegmatite at the lowest cost, so that the mica may increase in proportion, and the larger firms are seriously turning their attention to the introduction of power in their mines.

Miners' wages are high at present in proportion to what they were a few years back. Now they vary from four annas six pies to six annas per day. Sirdars or native foremen are paid from seven annas to seven annas six pies per day, and women and boys from two annas to three annas per day.

The writer does not agree with the advocate for overhand stoping in all cases. Every mining engineer knows that circumstances rule the case, the nature of the deposit and other conditions decide the method to be employed. If overhand stopings were used, where one has to deal with semi-savages there would be hundreds of accidents daily from falls of the roof. The miners, who are most careless in their work when not watched, will not take the trouble to sound the roof so as to break away unsafe parts. A case happened in the district not long ago. A miner working in a certain mine was told by his munshi to adopt the system, as it was the easiest way of getting large quantities of mica without much exertion on his part, and the consequences were that the man paid for the experiment with his life. Besides these dangers, drilling overhand with a drill bit and hammer is not so easy a task. Moreover good mica may be buried under the blasted material.

The writer, from experience gained in the field, intends to use overhand stoping where necessary, when his power plant is laid down, but not necessarily in every case. There, certainly, are many advantages, but the disadvantages at present overbalance the advantages, and the adoption of such a method would result in the closing down of many mines that are a commercial success at present.

There is no better system of mining suited to mica than a modification of the "Transverse stoping with filling" which is the system adopted by the writer at the "Alukdeah Champion Lode" and "Sootea." Naturally it is admitted

that there may be great difference of occurrences which may necessitate a still further modification or the adoption of another method better suited to the special occurrence.

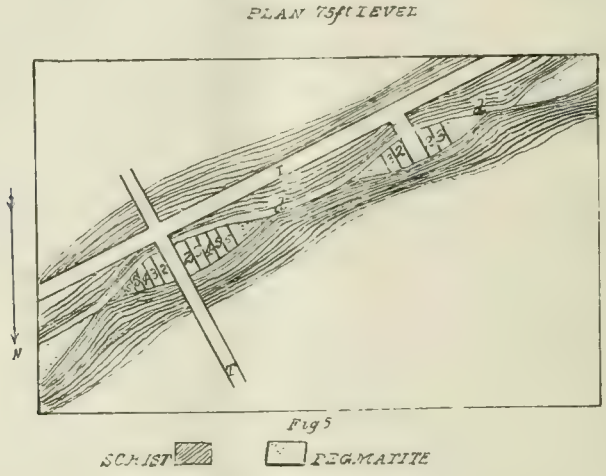


Fig 5

The plan, Fig. 5, of the 75-ft. level shows one method of working. The adit cuts through the lode, then the exploratory drift will be run along the hanging wall of the lode, and will therefore follow it in all its irregularities, checking the direction and continuance of the lode. After this the main haulage way *L* is driven in a straight line so as to allow the trolley free run, then the cross cuts *2*, *2*, are driven 8 × 10 ft. and the lode worked out. After the mica has been removed, broken rock is shot through the winze, connecting the two levels, to fill the opening. The cuts 3, 3, are treated in the same way, and so the work continues, as one level is completed the next above is started and carried on in the same manner until the entire lode is worked out. The material stoped in the upper level is shot down to the main haulage way through connecting chutes.

MILLING AND USES OF MICA.

The books of mica after being taken from the stopes are brought to the surface and split into pieces $\frac{1}{8}$ inch in thickness, tied in bundles with the bark of a creeper (*chope*) and taken to the factory where the pieces are cut by the sickle (all large cracks and rough edges being removed), sorted according to the various sizes. No. 4 grade, 6 square inches and upwards, is packed in boxes and shipped to the London market, and No. 5 and 6 are converted into films at the splitting factory. These films are also packed and sent to the London market; they are mostly purchased by micanite manufacturers, who convert them into micanite or mica board.

A sheet of paper, the proposed size of the board, is laid on a flat surface and coated with shellac over which the films are laid. Alternate layers of shellac and films are now applied until the required thickness is attained. Care is taken that the films in each layer break joint with those above and below. This board has to be under great pressure while baking. Shellac is used as the binding substance because it has very high insulating properties and has been found by experiments in practice to be next best to dry air as an insulator.

Scrap mica is used for making mica mats. These mats are used as thermal insulators for covering boilers and for protection against fire. They are used on the English Railways, and on H.M.S. *Drake* for boiler lagging, and there is no reason why they should not be used on the Indian Railways, etc., if manufactured in the country. By lagging is meant the covering put around a boiler for the purpose of preventing radiation of heat.

Mica now thrown away on the waste heap contains

many clear sheets 1″ × 1″ which are very largely used for fuse boxes, cut out boxes, insulating lamp, sockets, and other small electrical work. Indian mica has been proved best for sounding diaphragms in phonographs, gramophones and telephones; this increases the demand for the 1″ × 1″ and 2″ × 2″ films. Mica is used as an insulation between commutator segments, for lining armature core slots, etc.

ECONOMICS.

The reason for excessive waste is that the question of costs has been neglected. This is shown, by taking a case in the district, as follows :—

A certain mine 75 feet deep utilizes 200 women, sitting in two rows on ladders, for hoisting the broken material and water from the mine. The full buckets containing water, and the baskets of broken material go up one row and the empties go down the other; there are 4 men kept at the base for filling the buckets and baskets. All this expense is incurred to keep 10 miners and a sirdar at work. The cost sheet shows :—

	Rs.
Sirdar per month	32
Skilled labour, 28 shifts @ Rs. 4-8 per shift ..	126
Stores	60
Hoisting and draining 28 shifts @ Rs. 39 per shift	1,092
Total ..	1,310

The cost of hoisting and unwatering is out of all proportion, and if an ordinary sinking pump and hoisting engine were installed, the price of the complete plant would be paid back in five months by the saving effected. This is only one of many cases.

The fact that there are large profits in spite of wasteful methods of mining is due to the natural richness of the mines, and good returns accrue in spite of mismanagement. Now mica-mining, like all other kinds of mining, is a money-making business, but is guided by science to a certain extent; and it would be best for all operators to pick out the best mines, and work them on scientific basis. Proper records should always be kept and all accounts carefully checked; then actual profit can be made in mica-mining.

If the following or some other regular system of costs were kept, there would be a better check on expenses, larger profits, and less waste.

1. Salaries (Europeans), manager, engineer, and assistants.
2. ,, (native) assistants, clerks, munshis, durwans, etc.
3. Labour (skilled), sirdars, miners, drill hands, basket makers, etc.
4. ,, (unskilled), helps, etc.
5. Timber men—carpenters and helps.
6. Timber.
7. Hauling—tramming and shovelling.
8. Hoisting.
9. Pumping.
10. Miscellaneous—presents and other items not entered elsewhere.
11. Hospital expenses, medicine, etc.
12. Water supply.
13. Mine lighting—candles, oils, or other means of lighting.
14. Explosives—dynamite, detonators, fuse, etc.
15. Steel—drills, chisels, etc.
16. Coal—used by blacksmith and boilers, if any.
17. Blacksmith and help.
18. Fire-wood for staff.
19. Food for horses.
20. Bonus to staff.
21. Insurance and freight.

22. Maintenance or repairs and renewals—mechanics, fitters, masons, ghramees and beldars.
23. Rent or royalty.
24. Taxes.
25. Building.
26. Purchases.
27. Sales.
28. London charges and agency.

Dressing or Milling.

1. Salaries—assistant in charge of factory or mill.
2. Labour (skilled), sorters, scrivers, cutters, pickers, and [splitters.
3. ,, (unskilled).

Splitting by hand a boy can give 4 lbs. of films daily, while a 1-h.p. machine, worked by the same boy, will produce 70 lbs. in a day of 8 hours.

The machinery for mica mat-making and for powdering, etc., is a factor of economy which leads to success. Every modern mica factory should be properly installed with these machines, and then if the profits do not redouble themselves, bad management will be entirely responsible. This has tersely been stated by an American expert. "The watchword of success is utility and economy—unintelligent management may easily swamp an enterprise which, in proper hands, would have proved a success."

The mica miner must realize that the factors which will bring in the largest profits in the mica business are the reduction of costs, the extraction of the largest quantities of mica at the least expense and in the shortest time, and the regulation of shipments to suit the market.

CAUSE OF FAILURE IN WORKING MICA ON SCIENTIFIC BASIS.

It has been stated more than once that mica mining on scientific basis in India has proved a failure, but it is

questionable whether scientific mining was ever carried on with due precaution. Were the peculiar occurrences of mica deposits well considered? The following quotation from an American source is very apposite :—

"The character of the ground determines the most economical method of its exploration, these explorations should be so planned as to cover the most ground with the least amount of exploratory work, and the work should be so laid as to avoid duplication of results. Now in the ground in which the chance of discovering valuable ore bodies is very slight, this tendency to run drifts too frequently is to be avoided. There are few mines where much money has not been thrown away by fruitless exploration of this character, when the sinking of a winze a short distance, or the raising of an upraise for a short distance, would have conclusively established the absence of pay ore bodies within the region explored without the rashness of running those frequent drifts through that barren stretch of country."

CLASSING, GAUGING AND VALUE OF MICA.

There are great variations in the classing and gauging of mica in different parts of the world. The writer thinks that the Indian gauging and classing, given below, is certainly the best of the better known systems and should be universally adopted.

Extra Special	..	64	sq.	in.					
Special	..	48	sq.	in.	to	64	sq.	in.	
A. I	..	36	,,	,,	,,	48	,,	,,	
No. I	..	24	,,	,,	,,	36	,,	,,	
,, II	..	15	,,	,,	,,	24	,,	,,	
,, III	..	10	,,	,,	,,	15	,,	,,	
,, IV	..	6	,,	,,	,,	10	,,	,,	
,, V	..	3	,,	,,	,,	6	,,	,,	
,, VI	..	1½	,,	,,	,,	3	,,	,,	

It is difficult to give any definite prices as there are great fluctuations in the market, owing chiefly to the supply exceeding the demand or *vice versa*, and to variance in gauging. Now, as the majority of the firms have insufficient capital from a mining standpoint, and are unable to stock, they are compelled to sell the mica as they procure it from the mines even when there is either a slump in output all round, or else a rush of good luck. In the latter case ordinary business prudence would prompt any thinking person to "put by for a rainy day" instead of shipping all his mica to London to be grabbed up by the middle men who are reaping a harvest while the poor miner is puzzling his head as to how he is to cover the losses incurred by the London sacrifice.

According to English price-lists the following are some of the prices per lb. paid for Indian mica:—

	Clear.	Slightly Stained.	Stained.
	s. d.	*s. d.*	*s. d.*
Ex. Special	.. 20 0	..	..
Special	.. 13 0	7 6	..
A I	.. 10 6	6 0	..
No. I	.. 7 0	5 6	5 2
,, II	.. 6 0	4 0	3 3
,, III	.. 4 6	3 3	2 2
,, IV	.. 3 3	2 3	1 6

V and VI are converted into films.

According to Mr Kilburn Scott [1] the following prices were paid for the following gauging:—

	s. d.	
2″ by 6″ ..	2 6	per lb.
2½″ ,, 6″ ..	4 6	,,
3″ ,, 6 ..	6 6	,,
3½″ ,, 6″ ..	8 0	,,

[1] Transactions Inst. M. M., Vol. XII, 1903.

If this be the case, it is very evident that if Indian mica were guaged according to the latter gauging, the profits would be greatly enhanced as No. I 24 sq. in. to 36 sq. in. fetches 7*s*. 3*d*. while $3\frac{1}{2}'' \times 6''$ or 21 sq. in. fetches 8*s*. Further, Mr. Kilburn Scott says that the prices for the same (duty paid) in America are from 25 % to 40 % higher. This is very probable, as the greater portion of the Indian mica eventually finds its way to America, through intermediate sources.

CONCLUSION.

Sharp competition in the mica industry, as in other mining industries, has done it good, and the leading firms have turned their attention to the introduction of power plants, power drills, pumps and other machinery.

In a district like Kodarma, where there are so many proved prospects, deep mining should be done on a large scale so that the business may be more profitable than has been the case hitherto. Of course, this means a sweeping change in the manner of carrying on the business; it will have to be carried out on broader lines, but the larger scale of operation will result finally in a considerable diminution in the average cost per maund.

The industry is so well established under European control in Bengal that, if all the petty miners in the district combined and introduced power plants, following the lead given by the larger firms, Bengal alone could supply the demand of the world at so low a rate that no other country in the world could compete with it.

DISCUSSION ON MR. DICKSON'S PAPER ON THE KODARMA MICA MINES.

Mr. T. H. Holland considered that Mr. Dickson's paper was just the kind required for the Institute. There has been

little or no regard paid to the recognised methods of mining in exploiting the Indian mica-deposits. The deposits of marketable mica are comparatively irregular in their shape and constitution, and consequently, while the old method of following the mineral from "book" to "book" results in most imperfect exploitation, the adoption of systematic operations involves an outlay of capital that would be risky without preliminary tests on an extensive scale of the nature of the deposit to be attacked. Mr. Dickson had adopted a judicious course between the two extremes: he recommends following the mica-bearing pegmatite to a depth of say 100 feet in the ordinary way, and then, having proved the nature and disposition of the mass of pegmatite, he organises his work in order to clean out every fragment of rock likely to contain mica of value.

Mr. Dickson apparently endorsed the criticism of the existing mining methods contained in his (Mr. Holland's) memoir on Indian mica (*Mem. Geol. Surv. Ind.*, Vol. XXXIV, Part 2). The old method of underhand stoping at the bottom a worm-like hole, incurred the danger of damage to valuable sheets of mica; it failed to take advantage of the comparatively loose nature of the coarsely crystalline pegmatite; it permitted the nightly accumulation of water at the working face, and involved a ridiculous and expensive way of removing mica, waste and water through the one opening at the surface reached by a string of cooly women. The practice—it can hardly be called system—of following the mica from "book" to "book" resulted in neglect of the fact that the pegmatite through which such tortuous holes are made, are generally large sheets, sometimes continuous and flat for considerable distances; sometimes they thicken out into lenticular bodies or form irregular boss-like masses; they never, however, have the

shape of the average Hazaribagh mica mine, and thus large quantities of pegmatite are left untouched by the miners, and areas are looked upon as worked-out where but a small fraction of the available mica has been touched.

It would be risky to burrow about in apparently barren pegmatite on the off-chance of meeting a valuable crystal of mica, but the system of proving the pegmatite sheet for a depth of say 100 feet would enable the miner, by planning systematic operations, to work out without much cost or risk the whole of the pegmatite body, and thus turn it to full account.

The speaker had advocated over-hand stoping in the secondary stage in order to take full advantage of the loose texture of the pegmatite and to keep a clean working face. Mr Dickson points out the danger to the miners involved by this system of work, and Mr. Holland readily agreed that where transverse stoping, followed by filling in with the waste, could be adopted, overhand stoping should be avoided. But in the memoir on mica to which Mr. Dickson referred, it was pointed out that "every occurrence has its peculiarity, and requires, consequently, a special form of attack; and the most economical system of working will consist of a judicious selection from the great variety of recognised mining practices, modified, if necessary, by the ingenuity and common sense of the manager, to suit the special local conditions" (*Mem. Geo. Surv. Ind.*, XXXIV, 85). Mr. Dickson deserved the thanks of the Institute for giving the members, among whom might be possible competitors in a comparatively limited field, the benefit of his experience in this very specialised form of mining.

Mr. Holland criticised the use of the term "ore" for the mica-bearing pegmatite. The word "ore" had retained its etymological meaning as a metalliferous body,

and one is hardly justified in extending it to a mica-bearing pegmatite.

The speaker also thought Mr. Dickson was writing beyond his experience in recommending the use of a 15-inch core drill in prospecting for mica. A 15-inch calyx drill would not be of much use in a mica-bearing "country," while a 15-inch diamond-shod crown would cost as much as many of the so-called mica-mines in the Hazaribagh district. On the whole, Mr. Dickson had given the best advice possible in advocating the practice of sinking on the pegmatite, making the work pay for itself while obtaining the information necessary to warrant a considerable capital outlay in shafts, cross-cuts and machinery.

Mr. Holland was glad to obtain the approval of a practical man for his advocacy in the memoir referred to of more "limited liability" concerns in mica-mining. He had pointed out the drawbacks arising from the act that the mines, being owned by individuals or small associations, were necessarily worked on the hand-to-mouth system, the expensive practice of merely following the mineral from "book" to "book" being naturally preferred to the risks attendant on a more systematic organization that would be justified only by increased capital and divided liabilities (*op. cit.*, pp. 82 and 86).

Coal and the Smoke Nuisance in the 17th Century.

Extracts from the Diary of John Evelyn.

BY

R. P. Ashton.

John Evelyn was born in 1620 and died in 1706, and left a diary extending from 1641 to within one month of his death. He was a careful noter of social, political and scientific progress. It is recorded that he was offered the Order of the Bath by King Charles II., but was better pleased to be nominated one of the Council of the newly-formed Royal Society.

The diary is well known, but probably the following extract will be new and of interest to many of the Institute members. It is dated 1656, 11th July :—

Came home by Greenwich Ferry, where I saw Sir John Winter's new project of charring sea-coale, to burne out the sulphure and render it sweete. He did it by burning the coales in such earthen pots as the glass-men mealt their mettall, so firing them without consuming them, using a barr of yron in each crucible or pot, which barr has a hook at one end, so that the coales being mealted in a furnace with other crude sea-coales under them, may be drawn out of the potts sticking to the yron, whence they are beaten off in greate halfe-exhausted cinders, which being rekindled make a cleare pleasant chamber fire, depriv'd of their sulphure and arsenic malignity. What success it may have time will discover.

The editor of an edition of the diary published in 1818 says :—

Some years ago Lord Dundonald revived the project, but with the projected improvement of extracting and saving the tar. Unfortunately

his Lordship did not profit by it. The Gas Light Company sell the coal thus charred, by the name of coke, for fuel for many purposes (1818).

This process will suggest the "Poora Koila" of Bengal, although it appears to have been conducted on a less wasteful method.

Sir John Winter knew nothing about by-products, or perhaps he would have anticipated the Coalite Co., Ld., in whose prospectus, we are told, the process consists in carbonising bituminous coal in flat rectangular retorts 10 feet in length, which are placed vertically in a gas-fired furnace, the temperature of which is kept at 800° Fahr., resulting in coalite and by-products.

Coalite, it is said, radiates more heat into a room than coal, burns without smoke, lights easily, and the fire keeps clear like Sir John Winter's "Greate halfe exhausted cinders."

Apparently Sir John Winter's schemes came to nothing, but Mr. John Evelyn did not forget the subject and, five years later, when to use his own words, "God had miraculously restored to us our Prince, a Prince of so magnanimous and publick a spirit," he wrote and presented to that Prince a pamphlet entitled "Fumifugium," the dedication of which is worth recording.

To the King's Most Sacred Majesty,—It was one day, as I was walking in Your Majesties palace at Whitehall (where I have sometimes the honour to refresh myself with the sight of your illustrious presence, which is the joy of your people's hearts) that a presumptuous smoke issuing from one or two tunnels neer Northumberland-house, and not far from Scotland-yard, did so invade the court that all the rooms, galleries and places about it were filled and infested with it; and that to such a degree, as men could hardly discern one another for the cloud, and none could support, without manifest incoveniency. It was not this which did first suggest to me what I had long since conceived against this pernicious accident upon frequent observation; but it was this alone,

and the trouble that it must needs procure to Your Sacred Majesty, as well as hazard to your health, which kindled this indignation of mine against it, and was the occasion of what it has produced in these papers.

The following extract from this pamphlet shows that Mr. Evelyn had a poor opinion of coal-mining from the sanitary point of view, while he evidently regarded the "Plague," now so familiar to India and then recurrent in England, as one of the effects of coal smoke!

Newcastle coale, as an expert physician affirms, causeth consumption, phthisicks and the indisposition of the lungs, not only by the suffocating abundance of smoake, but also by its virulency: for all subterrany fuell hath a kind of virulent or arsenical vapour rising from it, which, as it speedily destroys those who dig it in the mines, so does it little and little, those who use it here above them. Therefore, those diseases (saith this Doctor) most afflict about London, where the very iron is sooner consumed by the smoake thereof, than where this fire is not used.

And, if indeed there be such a venemous quality latent, and sometimes breathing from this fuell, we are lesse to trouble ourselves for the finding out of the cause of those pestilential and epidemical sicknesses (epidemiorum causa enim in Aere, says Galen) which at divers periods have so terribly infested and wasted us: or, that it should be so susceptible of infection, all manner of diseases having so universal a vehicle as is that of the smoake, which perpetually invests the city.

London in those days must have been worse than Calcutta before Mr. Drover came to this city judging from the following:—

So corrosive is this smoake about the city, that if one would hang up gammons of bacon, beefe or other flesh to fume, and prepare it in the chimnies, as the good housewives do in the country, where they make use of sweeter fuell, it will so mummifie, dry up, waste and burn it, that it suddainly crumbles away, consumes and comes to nothing.

The consequence then of all this is, that (as was said) almost one-half of them who perish in London, die of phthisical and pulmonic distempers; that the inhabitants are never free from coughs and importunate rheumatisms, spitting of impostumated and corrupt matter.

It comes as a surprise to read that, a hundred years before the days of John Gilpin when Islington was a country village, one who knew London well could write of it like this :—

I forbear to enlarge upon the rest of the conveniencies which this august and opulent city enjoies both by sea and land, to accumulate her encomiums, and render her the most considerable that the earth has standing upon her ample bosome : because, it belongs to the Orator and the Poet, and is none of my institution : but I will infer, that if this goodly city justly challenges what is her due, and merits all that can be said to reinforce her praises, and give her title, she is to be relieved from that which renders her less healthy, really offends her, and which darkens and eclipses all her other attributes. And what is all this, but that hellish and dismall cloud of sea-coal ? which is not only perpetually imminent over her head, for as the Poet

Conditur in tenebris altum caligine Coelum,

but so universally mixed with the otherwise wholesome Aer, that her inhabitants breathe nothing but an impure and thick mist, accompanied with a fuliginous and filthy vapour, which renders them obnoxious to a thousand inconveniences, corrupting the lungs, and disordering the entire habits of their bodies; so that cathars, phthisicks, coughs and consumptions rage more in this one city than in the whole earth besides.

I shall not here much descant upon the nature of smoake, and other exhalations from things burnt, which have obtained their severall epithetes according to the quality of the matter consumed, because they are generally accounted noxious and unwholesome, and I would not have it thought, that I doe here fumos vendere, as the word is, or blot paper with insignificant remarks : it was yet haply no inept derivation of that critick who took our English, or rather Saxon appellative, from the Greek word $\zeta\mu\nu\kappa\omega$ corrumpo, and exuro, as most agreeable to its destructive effects, especially of what we doe here so much disclaim against, since this is certain, that of all the common and familiar materials which emit it, the immoderate use of, and indulgence to sea-coale alone in the City of London, exposes it to one of the foulest inconveniencies and reproaches that can possibly befall so noble, and otherwise incomparable, city : and that, not from the culinary fires,

which for being weak, and lesse often fed below, is with such ease dispelled and scattered above, as it is hardly at all discernable, but from some few particular tunnells and issues, belonging only to brewers, diers, lime-burners; salt and sope-boylers, and some other private trades, one of whose spiracles alone does manifestly infect the Aer more than all the chimnies of London put together besides. And that this is not the least hyperbolic, let the best of judges decide it, which I take to be our senses: whilst these are belching it forth their sooty jaws, the City of London resembles the face rather of Mount Etna, the court of Vulcan, Stromboli, or the suburbs of Hell, than an assembly of rational creatures, and the imperial seat of our incomparable Monarch. For when in all other places the Aer is most serene and pure, it is here eclipsed with such a cloud of sulphur, as the sun itself, which gives day to all the world besides, is hardly able to penetrate and impart it here; and the weary traveller, at many miles' distance, sooner smells than sees the city to which he repairs. This is that pernicious smoake which sullies all her glory, superintending a sooty crust or furr upon all that it lights, spoiling the moveables, tarnishing the plate, gildings, and furniture, and corroding the very iron bars and hardest stones with those piercing acrimonious spirits which accompany its sulphure, and executing more in one year, than exposed to the pure Aer of the country it could effect in some hundreds.

. . . . piceaque gravatum
Foedat nube diem;

It is this horrid smoake which obscures our churches, and makes our palaces look old, which fouls our clothes, and corrupts the waters, so as the very rain and refreshing dews which fall in the several seasons precipitate this impure vapour, which, with its black and tenacious quality, spots and contaminates whatsoever is exposed to it.

. . . . Calidoque involvitur undique fume.

It is this which scatters and strews about those black and smutty atomes upon all things where it comes, insinuating itself into our very secret cabinets, and most precious repositories: finally, it is this which diffuses and spreads a yellowness upon our choicest pictures and hangings: which does this mischief at home; is Avernus to fowl, and kills our bees and flowers abroad, suffering nothing in our gardens to bud, display themselves, or ripen; so as our anemones, and many other

choicest flowers, will by no industry be made to blow in London, or the precincts of it, unlesse they be raised on a hot-bed, and governed with extraordinary artifice to accelerate their springing, imparting a bitter and ungrateful taste to those few wretched fruits which, never arriving to their desired maturity, seem, like the apples of Sodome, to fall even to dust when they are but touched.

His essay proceeds to inveigh against intra-mural cemeteries, but he soon gets back to the evils of "Sea-Coale" and noxious trades.

Especially such as in their work and fournaces use great quantities of sea coale.

The sole and only cause of these prodigious clouds of smoake, which so universally and so fatally infest the Aer, would in no city of Europe be permitted, where men had either respect to health or ornament. Such we named to be brewers, diers, sope and salt-boylers, lime-burners and the like.

Culinary fires, which charking would greatly reform, contribute little or nothing in comparison to these foul-mouthed issues and curles of smoake which do "coelum subtexere fumo" and draw a sable curtain over heaven.

Evidently he still had a grudge against "sea-coale," for, twenty-five years later, on 1st March, 1686, his diary records :—

"Came Sir Gilbert Gerrard to treate with me about his son's marrying my daughter Susanna . . . . but after severall meetings we brake off on his not being willing to secure anything competent for my daughter's children, besides that I found most of his estate was in coal pits as far as Newcastle.

Largely as a result of Mr. Evelyn's efforts encouraged by the easily-made promises of the King, a bill was drafted to deal with the smoke of London, but it never became law.

"We have a Prince," says Mr. Evelyn in his dedication to the reader, "who is determined to be a father to his country." The Prince devoted himself to this determination but the smoake of London remained unabated.

Meeting at Sodepore, March 2nd, 1908.

By the kind invitation of the Bengal Coal Company, Limited, a meeting took place at the collieries of the Company at Sodepore on Monday, March 2, 1908. The members were shown the electric plant on the surface and underground, and were most hospitably entertained at tiffin and tea and in fact throughout the day. Members who had collected at Asansol by special trains from Jherria and Raneegunge and by special carriages attached to the ordinary train from Calcutta, were taken thence into the colliery sidings at Sodepore by a special train at 8-30 A.M.

As it was impossible for more than a limited number to see the machinery at one time, the following parties were arranged: *No.* 1 *Party*—G. F. Scott, R. Thomas, J. Karpelles, W. Porter, W. Dring, H. H. Macleod, T. H. Ward, J. J. Turnbull, W. Miller, Tyson Wolff, S. Heslop, J. R. Wilson, R. Hood Haggie, S. L. Maddox, H. H. Hayden, P. Brühl, St. J. Stephens, G. Sutherland, W. Heycock, G. LeMaitire. *No.* 2 *Party*—A. Sheridan, A. Whyte, G. C. Lathbury, W. Griffiths, R. Mitchell, E. H. Roberton, W. McFarlane, H. G. Graves, B. Heaton, J. Grundy, G. Adams, H. Thomson, W. Morrison, R. Ashton, T. Fleischer, A. L. Davies, L. Biddle, L. Edwards. *No.* 3 *Party*—G. Rennison, F. Heilgers, E. Patterson, C. Armstrong, A. Creet, J. Millar, H. Brown, W. Augier, C. Ambler, E. Forbes, J. Keene, H. Bull, P. Keelan, L. Jacobs, N. C. Sircar, T. Hodgkinson, R. Barnard, W. Hannaford. *No.* 4 *Party*—G. George, W. Lawrie, G. Gough, W. Phillips, W. Forster, J. Nierses, H. Wilkinson, C. McCale, R. Heron, A. Bennertz, J. Herriott, W. Ironside, G. Miller, F. Owen, D. Blair, O. Ernsthausen, A. Keelan, M. Quin.

No. 5 *Party*—A. T. Rose, F. Leighton, C. Colvin, P. W. Scott, J. Wylde, N. Bond, A. Gill, Dr. O'Connor, Dr. McConnel, R. Jones, C. Nairne, T. Morrison, R. Barrowman, H. Walker, T. LaTouche, G. Shearer, O. Loving, E. C. Agabeg, C. Veasey. *No.* 6 *Party*—R. S. Davies, G. Pitt, W. Rees, P. Ashcroft, H. Cooper, Dr. Christian, T. Chrystle, F. Marley, B. Brodhurst, A. C. Hills, P. Mitchell, D. Davies, W. Jerome, W. Lee, W. Glenck, R. Kotthaus, J. Dixon, R. G. D. Thomas.

In order to avoid confusion members of parties on arrival at the Colliery formed themselves in their respective groups. No. 1 Party at once went down No. 6 Pit and No. 2 down No. 5 Pit ; No. 3 and 4 went to the Generating House, while Nos. 5 and 6 walked over to the quarry workings.

The following description of the plant was handed to each member.

ELECTRIC INSTALLATION AT THE BENGAL COAL COMPANY'S SODEPORE COLLIERY.

Power-house Buildings.

The Power-house is situated at No. 6 Pit, this being the most central position for distribution. The size of the building is 50 ft. × 45 ft. The whole of the machinery and switch gear is placed on the one level, while the steam pipes and cables are led into the basement provided for the purpose. In the Power-house is erected an overhead Crane which has a span of 12 ft. and travels the full length of the building. This Crane is made by Messrs. Herbert Morris and Bastert, and is operated by hand-power with travelling, transverse and hoisting motions, and fitted with automatic sustaining brake. The capacity of the Crane is 8 tons.

Boilers.

Steam is supplied to the engines by two Arnold & Co.'s Lancashire-type boilers. The length of each boiler is 30 ft. and diameter 7 ft. 6 ins., the working pressure being 120 lbs. per square inch. Each boiler is fitted with Arnold patent solid welded barrel-shape flues. Water is supplied to the boilers by means of a "Rapid" Injector, and as a stand-by a "Tangye" Duplex Pump is installed.

Generating Plant.

Two generating sets, supplied by Messrs. Balmer, Lawrie & Co., of Calcutta, are installed in the Power-house. Each set consits of a "Robey" Class E Coupled Fixed Horizontal Engine fitted with automatic trip expansion gear; diameter of each cylinder 14 in., length of stroke 30 in., speed 120 R.P.M., capable of developing 300 B.H.P. with a steam pressure at engine stop valve of 100 lbs. per sq. in., combined with a "Johnson and Phillips" three-phase mesh connected alternator of the revolving field type having an output of 200 K.W. at 2,200 volts, periodicity 50 cycles per second. The rotor or field magnet system of the alternator is mounted direct on the engine shaft, and each set is furnished with a direct-current shunt-wound multipolar exciter generating at a pressure of 115 volts and driven by ropes off a pulley fitted on the engine shaft.

These sets are designed for running in parallel when required.

Transmission Line.

The poles for the Transmission Lines are of cast-iron. The conductors are of hard drawn solid copper wire, and are supported on triple shed high tension porcelain insulators. The lines are protected at each end by single pole Horn lightning arrestors.

Transformer Houses.

There are three Transformer Houses at Nos. 5, 6 and 7 Pits respectively. Each house contains two oil-cooled, three-phase transformers. Nos. 5 and 7 Transformers have an output of 25 K.V.A. each, and No. 6, 85 K.V.A. In each house is a high tension switchboard fitted with two three-way switches similar to those on the main board. There is also a low tension switchboard in each house fitted with switch fuses and an earth detector.

Connecting Cables between Transformer Houses and Underground Distributing Stations.

These are three-core cables, being double wire-armoured and bitumen-insulated, and are supported in the shafts by means of wood clamps attached to iron ropes which are suspended from girders fixed at the top of the shaft.

Underground Distributing Stations.

These are three in number and are situated close to the shafts. In each station is a low tension switchboard fitted with three-way oil break switches and an ammeter and voltmeter.

Steam Exciter.

A Steam Exciter, supplied by Messrs. Scott and Mountain, Ltd., is also installed in the Power-house. This set consists of a high-speed vertical engine coupled direct to a shunt-wound four-pole dynamo. The engine is of the open type, with a cylinder 7 in. diameter and having a 6-in. stroke running at 350 revs. per minute. The dynamo has an output of 100 amps. at a pressure of 110 volts.

Exciter Switchboard.

The Exciter Switchboard is composed of three panels, one for the steam exciter and one each for the rope-driven exciters, and is fitted with a voltmeter, an ammeter, and a shunt regulator for each exciter. Switches are also provided to enable the alternators to be excited either from their own coupled exciters or from the steam exciter.

Main High Tension Switchboard.

This board consists of six slate panels, and is arranged for controlling the two generators and four distribution circuits. On each generator panel is an electrostatic voltmeter, a three-pole oil break high tension 80-amp. switch provided with overload trip coil operated by transformer in two phases.

The distributing panels each contain a three-way switch, an ammeter, and earth detector.

On the high tension board are also a synchronising voltmeter lamp and plugs for enabling the two alternators to be paralleled.

Distributing Cables.

These are three-core bitumen-insulated cables and are suspended from insulators attached to angle-iron fixed in the side of the coal.

Haulage Gears.

Two Haulage Gears are at present installed in No. 6 Pit. These gears are supplied by Messrs. Scott & Mountain, Ltd., and are of the main rope type. The Drums are fitted with Hall's patent friction clutch. The Drum, Gearing and Motor are fitted to a steel frame, and the latter is designed in convenient sections to admit of its being easily lowered down the pit. Each haulage is driven by 60 H. P.

Motor through gearing. The rope speed of the haulages is 5·35 miles per hour.

PUMPS.

There are six pumps on the Colliery, two of which are at present in use. These pumps are made by Messrs. Scott & Mountain, Ltd., and are of the three-throw type, the rams being 5 in. diameter and having a 7-in. stroke. Each pump is fitted with interchangeable valve boxes, and is capable of raising 84 gallons per minute, against a vertical head of 450 ft. Each pump is driven by a 25 H. P. Motor through cut gearing.

At one o'clock the members gathered under a shamiana for tiffin, when the chair was taken by Mr. Thomas, Chairman of the Bengal Coal Company, supported by the President of the Institute, Mr. W. Miller, Mr. H. McLeod and Mr. G. F. Scott, the general manager of the Company.

Mr. W. Miller, President, in the name of the Institute, thanked the Bengal Coal Co. through Mr. Thomas for the very kind invitation they were so good to extend to the Members of the Institute to visit and inspect their Sodepore Collieries on this occasion. It was to such invitations that the Institute looked, to be able in a great measure to carry out the chief objects for which the Institute was established, *viz.*:—

(i) To promote the study of all branches of mining and geology.

(ii) To encourage, assist, and extend knowledge and information connected with mining, etc.

Their inspection of the Sodepore Collieries to-day had added very considerably to their knowledge and information. They had seen an up-to-date electric installation,

which, to say the least of it, does the Bengal Coal Co.'s Chairman, his Co-Directors, the Superintendent and other officers of the Company the greatest credit.

No other Indian Coal Company has as yet been so bold as to make such an important venture, but it may safely be said, after what has been seen to-day, *viz.*, Electric Power so successfully applied to underground Pumping and Haulage, and also to Coal Cutting by Machinery, by means of Auxiliary Underground Air Compressors, that some among them would be set thinking. Doubtless before long, many of our Coal Companies would follow the lead of the pioneer Coal Company in India.

The Bengal Coal Co. had conferred a great honour on the Institute in inviting it, and he desired in the name of the Institute heartily to thank Mr. Thomas, and his Co-Directors, also Mr. Macleod, the Superintendent, Mr. Scott, the Chief Mining Engineer, and all the other officers of the Company, for all the trouble they had taken to make the visit so interesting and instructive. They had been very pleased with all they had been shewn and felt under a very deep debt of gratitude to them for giving us the opportunity to extend their knowledge and information. Not only had they been afforded the opportunity of spending a pleasant and useful day, inspecting the Sodepore Collieries, but they also had heartily to thank Mr. Thomas for entertaining them so hospitably to so excellent a lunch. They highly appreciated all the kindness and hospitality which had been so lavishly expended on them, and would look upon that invitation and meeting as one of the red-letter days in their Institute's history.

In replying to the toast Mr. Thomas pointed out that

the spirit of co-operation, which led to the formation and harmonious working of the Institute must also prevail amongst the trade if it was to follow up its present success. It was of the highest importance that there should be an absence of any secretive spirit with regard to the developments of their methods and machinery. With that object of showing the latest developments, the Company, of which he was Chairman, had invited the members on that occasion. He then introduced Mr. Wilson, the new Chief Inspector of Mines for India.

Mr. J. R. R. Wilson, Chief Inspector of Mines in India, said he was very much obliged to them for the heartiness of their reception and for their great concern for his health. As they had been told, he had come out here to succeed Mr. Pickering, a man for whom they all had a great respect. Only that morning he had received a letter from him, and he asked him to give his best salaams to his Indian friends: that he took to mean the present company. So far he had seen a little, but not very much, of their Mining. He had been down a few coal mines and several mica mines, and had been along the length of one of their coalfields. It would, therefore, at this stage, be the height of impropriety on his part either to express an opinion about their systems of working or venture to criticise their methods of management and adminstration. He came from a district in the old country where mining is extremely modern and up-to-date, where the equipment leaves very little to be desired, and where the men controlling the organisations are absolutely at the head of their profession. In spite of that he wished to assure them that as far as was humanly possible, he had come here without any prejudices. He was prepared to look at Indian mining

from the standpoint of India. The conditions, of course, were so very different: their seams of coal were wonderful, their labour presented quite a new problem, and he was given to understand, the facilities for transporting the material from the mines was not in every case absolutely ideal.

He thought, and he believed he had always been of the opinion, that it was the duty of an Inspector of Mines to administer the Mines Acts without unduly harassing the industry. Any little success he might have attained at home had been due entirely to the fact that he had endeavoured to secure the cordial co-operation of proprietors, mining engineers and managers of mines. He saw no reason why similar methods here should not be equally successful. As the Chairman had said, the position of an Inspector is often not only a very arduous one, but one of great responsibility. Alone, he might toil on and perhaps accomplish something; but, with assistance, with sympathetic help, he might even become a great success and of value to the industry generally. He thought he had had the reputation of being a man of his word; time alone could prove that trait of character to them; but with this in view, he would tell them that he proposed to rely upon them—in short, he was prepared to trust them.

Mr. Haggie followed, and shortly dealt with the advantages of electric distribution of power as a method of economising in saleable coal. He advocated percussive types of coal-cutters driven from adjacent and electrically driven air-compressors in the fashion they had just seen underground. The question of central generating plants *versus* separate plants owned by the several collieries was also shortly discussed.

Discussion on "Fighting a Colliery Fire."

(*Continued from p.* 39, *Part I, Vol. III.*)

Mr. R. R. Simpson writes that he regrets that owing to Mr. Pickering's absence in England he is unable to collaborate with him in replying to the discussion. He was unable to be present at the meetings at which the paper was discussed, but is glad to learn that a considerable number of members have joined in the discussion. Mr. Griffiths' analysis of the evidence on the subject of the air-blast or explosion is most valuable. Explosions caused by the closing in of fire areas are not uncommon. An interesting case was recently cited by Mr. Joseph Dickenson,* formerly H. M. Inspector of Mines in England. In this instance the district was very gaseous, and a blower of gas became ignited by blasting operations. Eventually the packing caught fire and it was decided to attempt to stifle the fire by shutting it off. As it was not thought safe to build stoppings, the sealing was done by means of two wooden doors. Four volunteers descended the shaft and in ten minutes returned, having closed the doors. Thirteen minutes later the mine exploded, going off like the crack of artillery. Had building off instead of closing doors on this occasion been adopted, all the persons engaged in the operations would have been killed. Again in the Courrières explosion it appears to be not unlikely that the coal-dust explosion was initiated by a gas explosion originating in an area walled off on account of fire.

* *Trans., Inst. Mining Engineers*, xxxiv, 2, 278.

It was not stated in the paper that there was *no* back-lash. Whether a fall took place or an explosion, a certain amount of back-lash was inevitable; but in the opinion of the authors the fact that back-lash was not perceptible was strong presumptive evidence that the effect was caused by a fall and not an explosion. Another point bearing out this theory is the character of the noise. It was a rumbling sound and not the sharp crack of an explosion. Further confirmation is lent by the somewhat long interval which elapsed between the noise and the rush of air at the pits. Mr. Griffiths' argument that the explosion followed the course of the in-take air is not convincing. The explosive effects were propagated to all parts of the mine, and were felt just as severely near the outcrop as in the neighbourhood of No. 4 Pit.

Mr. Griffiths' eye-witness was hardly correct in his facts. No. 17 Pit was upcasting perceptibly during the whole of the time that the scaffold was being fixed. At the time of the air-blast there was not a thickness of 18 inches of sand and mud on the scaffold. Only a small amount of clay had been thrown round the edges of the scaffold, and the blast did not remove the sheets of corrugated iron, but merely turned up the edges of the sheets next the shaft walling. Mr. Griffiths' graphic word picture of the probable condition of the atmosphere of the mine prior to the air-blast was ingenious, but hardly borne out by the facts. Probably as much air was being drawn from the openings near the outcrop as from the dams. In the opinion of those present the sound came from a point to the north of No. 17 Pit and not from a point midway between pits Nos. 17 and 21. Taking all the facts into consideration the writer is still of the opinion that no explosion of gas took place.

One of the most surprising sequels to the fire is the rapid rate of cooling shown by Mr. Maltby's temperature observations. This fact shows the extremely porous character of Indian coal measure strata.

Mr. Chrystle's observations on the probable cause of the fire are full of interest, but it may be pointed out that the fire did not originate in the small pillars to which he refers, but near larger pillars to the west. The writer carefully examined these pillars but could see no trace of crushing.

Mr. George's suggestions that it would be useful to have the combined experience of the Institute as to the effects of subsidence on the surface is a useful one. He would be very glad if members would either communicate their experiences to the Institute in continuation of the discussion, or write to him privately on the subject. The depth and thickness of the seam, the nature of the strata and the amount of subsidence are the principal points on which information is required.

In conclusion it is pleasant to note that the idea of the establishment of rescue stations has received support from influential members. It is suggested that a small committee of members of the Institute be appointed by the Council to report on the practicability of the proposal.

Electric Machinery for Collieries.

Mr. R. Hood Haggie, as mentioned on p. 41, Vol. III, Part I, showed a few lantern slides of electrical machinery in use in collieries and mines in Great Britain. Some of these are reproduced in the accompanying illustrations from blocks lent by him.

Figure 1 is an up-to-date engine-room with three slow-speed horizontal engines with flywheel alternators. It shows the compact arrangement and also the great advantage of this class of engine which most colliery engineers are used to, and affords the engine-driver every facility for oiling them and giving proper attention whilst running. The exciters in this case are driven by ropes off the crankshafts, the switchboard being at one end and the whole arrangement being specially to meet the requirements of the Home Office rules for electricity in mines; and although these regulations are not enforced in India, they are drawn up in such a way that the compliance with them, besides giving greater security to the man in charge, also minimises the risk of breakdown.

Figure 2 shows a portable endless haulage gear made in sizes from 5 to 20 H.P., and Fig. 3 shows a similar main rope gear. The double drum haulage is of specially strong construction and arranged to take to pieces easily for ready handling in the pit. A special clutch arrangement is used of simple construction and yet made so that the tubs can be started easily from the bottom, and a minimum of slip when up to full speed. The brakes are specially strong, and the whole gear is designed to suit the severe conditions found in coal-mines.

Figure 4 shows a three-throw pump with girder bed, standard design, with all parts independent and interchangeable. Figure 5 is a similar pump for heads up to 1180 feet delivering 250 gallons per minute. All the pump barrels are cast separately and are interchangeable, as also are the delivery and suction valves. The rams are solid gun-metal and not cast-iron with a gun-metal covering. The bearings are specially designed to suit the head, and the gearing is also very strong. These pumps are largely used where great efficiency and reliability are required.

Figure 6 shows a cheaper kind of trunk type of pumps for heads up to 200 feet to meet the demand for a cheaper pump than the one with all parts independent and interchangeable. Figure 7 shows a smaller portable pump with motor, of which many are in use.

Figure 8 shows a portable compressor directly coupled to the motor.

Figure 9 is a single-ended stationary compressor with its motor.

An electrically-driven compressor for driving drills or coal-cutters, placed near the face, saves the loss by friction and leakage in the joints of the air-pipes, and this arrangement combines the efficiency of electric transmission with the reliability of compressed air-driving.

The most trying conditions at a colliery are found at the face, and the simple compressed air-engine naturally appeals to the colliery manager for this position. This compressor takes up a small amount of room, and may be quickly dismantled if necessary; and if mounted on a trolley it can be easily moved to a different part of the colliery, the cables being much more easily taken up and refixed than is the case with air-pipes.

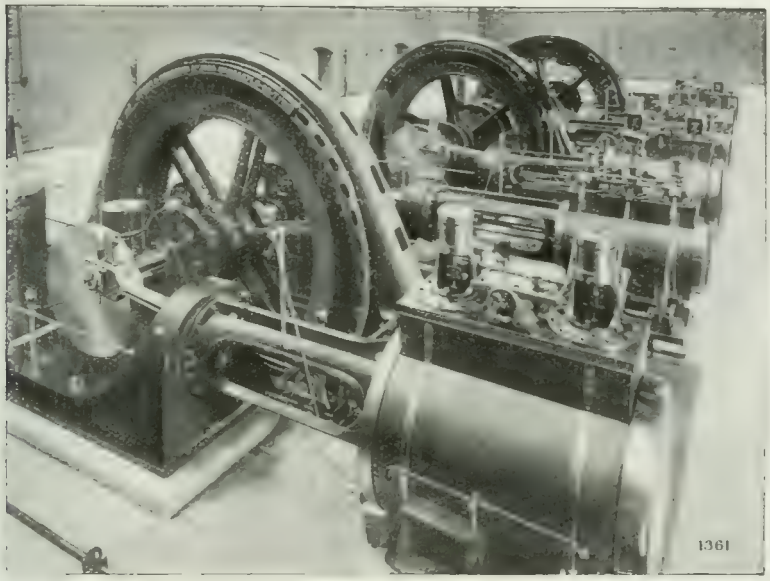


Fig. 1.

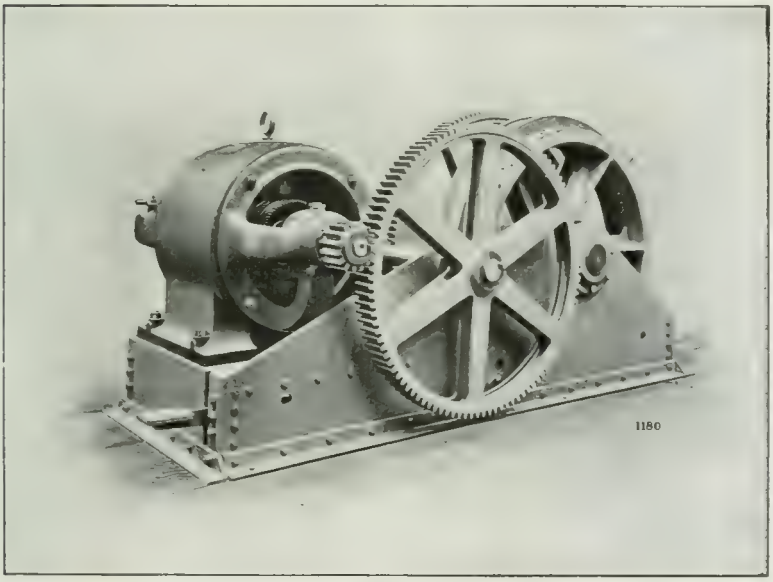


Fig. 2.

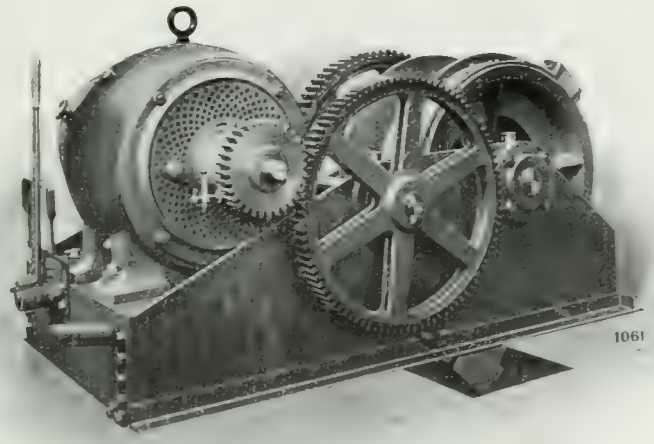


Fig. 3.

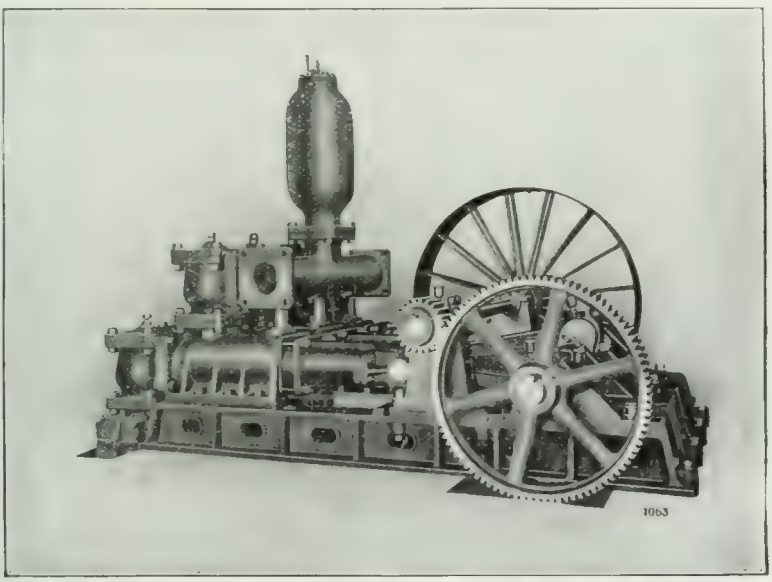


Fig. 4.

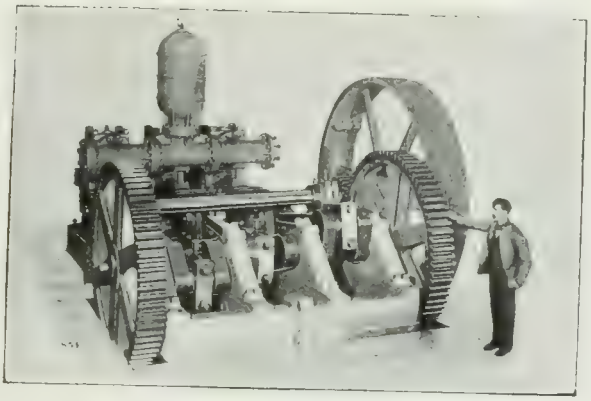


Fig. 5.

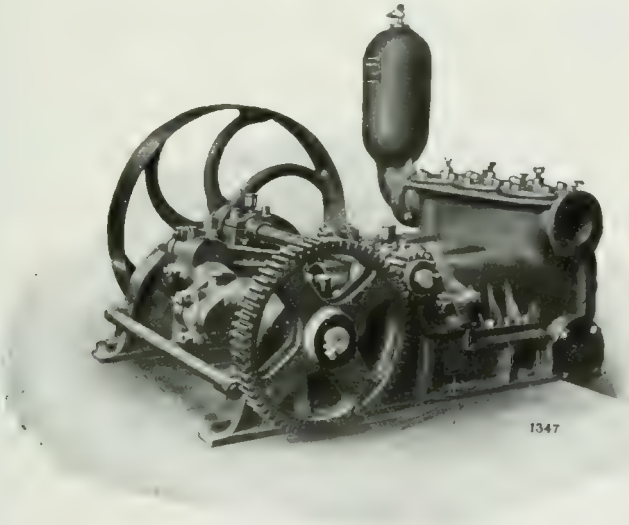


Fig. 6.

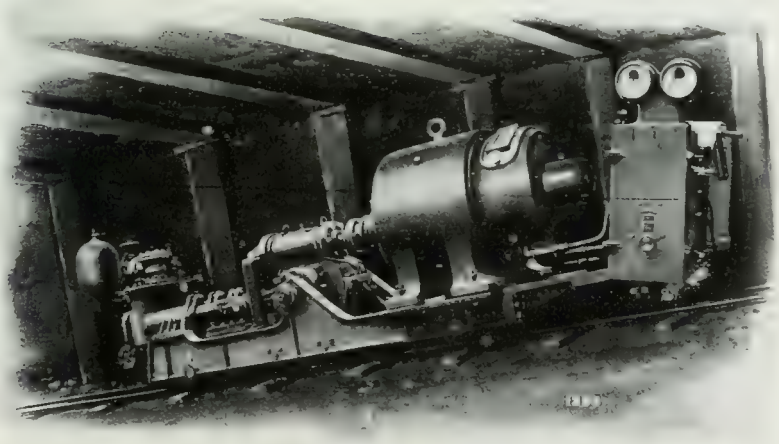


Fig. 7.

General Meeting.

Held at Jherria, July 13, 1908.

A General Meeting of the Institute was held at the Jherria Club on Monday, the 13th July, 1908, at 9-30 A.M. The chair was taken by the President, Mr. W. Miller, supported by the following members of Council :—Messrs. G. F. Adams, H. G. Graves (Hon. Secretary), B. Heaton, S. Heslop, T. D. La Touche (Hon. Treasurer), J. J. Turnbull, and by over fifty other members.

The President announced that there were four new papers to be read, but before doing so he put the following resolution, which was seconded by Mr. S. Heslop :—

The Mining and Geological Institute of India tender their most hearty congratulations to Sir T. H. Holland, K.C.I.E., F.G.S., F.R.S., A.R.S.M., their first President, on his admission to the Most Eminent Order of the Indian Empire as Knight Commander.

The resolution was carried unanimously with acclamation.

The following paper on Central Power Stations for the Coal-fields was then read by Mr. W. A. Lee.

Central Power Stations for the Coal-Fields.

BY

Arthur G. Marshall and W. A. Lee.

It was originally proposed by Mr. Miller, President of the Institute, and by the Secretary, that Mr. Marshall should write a paper on this subject, but on discussing the matter it was suggested that the paper would probably have more value if it was written by the authors in collaboration, as the subject would then be put before the members from different points of view, for, as everyone is aware, engineers and coal-miners do not always agree in their conclusions.

DOES IT PAY?

The question of the electrification of coal-mines has been a matter of considerable discussion in these fields for some years, especially since the coal-fields power license was granted to Messrs. Hoare, Miller & Co. This matter really resolves itself into two questions—

A.—Does it pay to electrify a coal-mine?

B.—If it pays, does it pay to take current from a power company or generate for oneself?

Question A must manifestly be answered first of all before it becomes worthwhile discussing B, although there are many cases of mines and factories where it would not pay to electrify unless current were taken from a power company.

As the authors have under consideration the case of the coal-fields of Raniganj and Jherria, attention may be called to some rather notable points in the present methods of working.

The principal uses for power on these fields lie at present in pumping, hauling, and winding. There is very little mechanical coal-cutting done, and practically no mechanical ventilation, and scarcely any lighting. It is therefore proposed only to consider the first three as regards present working, dealing with the other uses for electric power when considering the advantages of electrification.

STEAM PLANT.

It will be easier to compare the present methods of working by taking an example representative of the work now being done. It is somewhat difficult to select a typical example because no two collieries are quite alike; some, for instance, are wetter than others; there are mines in this field which drain several others in their vicinity. Some mines again raise more coal from an incline or a pit than others, and some inclines are steeper than others.

As an example, imagine a mine with four inclines and two pits. It may be taken to require the following horse-power :—

(1) Four inclines, each hauling 2,000 tons per month, up an incline of, say 1 in 8, a distance of 2,000 feet.. .. .. .. = 48 H.P.

(2) Two pits, each winding 4,000 tons per month, a vertical height of 400 feet .. .. = 60 H.P.

(3) Four dip pumps lifting 30 gallons of water per minute, a height of 100 feet .. .. = 4 H.P.

(4) Two main pumps lifting 100 gallons of water per minute, a height of 150 feet .. .. = 9 H.P.

(5) One main pump, 200 gallons per minute, 400 feet = 24 H.P.

The total of this is 145 H.P., which represents the actual theoretical horse-power required, the mechanical equivalent of the work done. In practice, allowance must be made for losses in gearing, etc., which amount to, say, 30 per cent. with economical working, so that the horse-power actually employed to do the work specified is about a total of 207 H.P. at the machines. With modern steam working and large units, it is quite possible to obtain a horse-power for every 2 lbs. of small Bengal coal per hour, or, in other words, this horse-power ought to be generated for 51 tons of coal per month provided that there are economical large machines reasonably near the boilers, and that waste due to idle time is a minimum.

These figures are entirely theoretical, and consideration must now be paid to what is actually being done on the average colliery property.

First of all, with regard to the inclines, the average incline is worked by a vertical boiler of say 20 H.P., and often the engine has seen its best days. The steam pipe, which probably blows at many joints, is some 60 to 100 feet in length. The boiler is working at a low pressure, and the shell encrusted with scale. The haulage is so designed and worked that the engine hauls say 7 tubs per trip, each holding two-thirds of a ton of coal, and thus could complete the monthly output in 40 hours. During the remainder of the month it is lying idle, but the depreciation, maintenance, repairs, and wages are going on all the time. The actual amount of coal used will be, say, 70 tons per month.

In the case of the winding engines, the same remarks as to the condition of the plant in many cases apply, but here there is as a rule at least one, and probably two or more, Lancashire boilers; the actual number of hours during which the plant is doing useful work lifting coal

will only amount to 120 per month, and the coal used for this purpose to 150 tons.

As to the pumping, a vertical boiler and a pump of Tangye type may be allowed for each incline dip, a small duplex for each incline main pump, and a Lancashire boiler with a Worthington pump for the pits. The consumption of coal is about 90 tons per month for each of the main pumps, and a further 90 tons for each dip pump, 180 tons for the pit pump. The total coal used on such a colliery for power purposes is therefore 1,320 tons per month. This is a moderate figure; many colliery managers admit that it cost considerably more than this proportion of the output.

Now this shows that whereas the horse-power actually used can be generated under the most economical conditions for 51 tons of coal per month, the actual working conditions of the Bengal coal-mines are such that 1,320 tons are required.

An argument in defence of this is often made that it is only slack that is being burned, and that therefore the coal costs nothing. This was never true, for the value of the coal to the mine is the money for which it can be sold, and slack has always had some value, say Re. 1 per ton, and is now worth, say, Rs. 4 per ton. It is admitted that a fair average value is Rs. 2 per ton, and many managers place it at a higher figure.

The manager of the imaginary mine has, therefore, to face the fact that owing to inefficient methods, his cost of power generation, in coal alone, comes to Rs. 32,000 per annum; and it is now proposed to show how some of it—in some cases all of it—can be saved.

Up to the present the cost of the labour has been purposely neglected, but before going on to other mat-

ters, some figures, given us by one mine-manager and confirmed by a number of others as being under and not overstated, may be quoted. The figures represent the actual working cost, apart from coal, of pumping about 90,000 gallons per day from an incline by means of the usual appliances—a small vertical boiler and a Tangye's pump:—

2 Khalasis	.. ..	Rs. 20-0-0	per month
2 Firemen	.. ..	,, 15-0-0	,,
2 Kamins	.. ..	,, 9-12-0	,,
Oil, 1 seer per day	.. ..	,, 5-0-0	,,
Pump leather	.. ..	,, 4-0-0	,,
Repairs and renewals	..	,, 20-0-0	,,
Fitters, proportion	.. ..	5-0-0	,,
Boiler inspection	.. ..	,, 2-0-0	,,
	Total Rs.	80-12-0	,,

At the price the power company will charge, the cost of current to do this work would be Rs. 60 per month. In this case the whole cost of working and maintaining the electric pump would be no greater than the cost of the steam pump in wages and repairs alone, so that if such a steam pump were replaced by an electric pump the whole of the coal now consumed in the boiler would represent the saving.

CENTRAL POWER STATIONS.

The next point to be considered is whether it pays or does not pay the mining company to take its power from a central station.

The points in which centralisation gains advantages over individual separate plants are as follows:—

(*a*) Reduced capital expenditure owing to the increased size of the units.

(*b*) Reduced capital expenditure owing to the increased diversity factor.

(*c*) Reduced capital expenditure owing to reduced amount of spare plant necessary in the power-house.

(*d*) Decreased standing charges owing to the larger size of plant.

(*e*) Decreased working expenses per unit generated owing to the better load factor and larger units of plant.

(*f*) Provision of better supervision and management than possible otherwise, for financial reasons.

These are details which chiefly concern the power company, and are the reasons why it is able to offer the mining company the following advantages:—

1. Cheaper power than can be generated locally.
2. Reduced liability to break down.
3. Advantage of highly skilled staff continuously at disposal.
4. Speedy execution of repairs and extensions.
5. Freedom for all responsibility for power supply.
6. Enormous reserve of power which can be drawn on whenever necessary.
7. Decrease of labour and troubles arising therefrom.

The advantages will now be dealt with in detail, first of all showing how it is that a power company is able to obtain its advantages, and their extent, and then dealing with the collieries and the benefits they receive.

(*a*) *Capital Expenditure.*—This, as has been stated, is reduced in three ways. The increase in the size of the units alone will account for a very considerable reduction, as the following table will show:—

Capacity of power station	Cost per kilowatt.
200 kilowatts	£ 25
500 ,, ...	,, 20
1,000 ,, ...	,, 18
5,000 ,, ...	,, 16
10,000 ,, ...	,, 14
50,000 ,, ...	,, 12

It is thus seen that the power company will be erecting

its stations at £14 to £15 per kilowatt, whereas the individual colliery company will probably be paying double this figure.

(*b*) The next point mentioned is the diversity factor. The diversity factor represents the proportion of the demand made by the machines connected to the supply mains to the demand that would be made on the power station supposing all the machines required their full power supply at the same instant.

In every factory, taken individually, it is possible that nearly all the machines will be in use at somewhere near full load at the same time, and the conditions on our imaginary colliery are nearly the same, and it is probable that at least 80 per cent. of the machines will be taking their full power at the same moment.

Now the imaginary mine has four haulages and two winding engines, but when this figure is multiplied by, say, 50, it will be easily realised by all that it is a practical impossibility for all these 200 haulages and 100 winding engines to be working at full load at the same time.

It is in fact found, in actual practice, that the diversity factor is in such cases over two and nearly two-and-a-half, that is to say, only about half or five-twelfths of the maximum possible demand is actually ever made. In other words, the plant in a power station, such as the one under discussion, is able to deal with, say, double the number of machines that a number of individual stations of an equal capacity, in the aggregate, would be able to deal with.

(*c*) Again, with regard to spare plant, in the case of each individual station with a capacity of say 200 kilowatts it will be necessary to instal a duplicate set, in other words have 100 per cent. spare plant.

In the case of the power company this proportion will be very considerably reduced, and will average about 20 per cent. to 25 per cent., varying, of course, with the growth of the station. This item, therefore, alone accounts for a saving of 25 per cent. in the capital expenditure in the power-house.

Generally speaking, it can be seen from the above details that the cost of a central power-station, to deal with such a load as that given by colliery machinery, is under one-fourth of the aggregate cost of the individual stations that would otherwise be necessary.

Now with regard to revenue expenditure. This is divided naturally under two heads:—

Standing charges.—Such as interest on capital, management, depreciation, etc.

Working expenses.—Such as wages, coal, stores, water, and a proportion of management, etc.

The former do not, to all intents and purposes, vary with the output of the station, whereas the latter vary in proportion to the increase of output.

(*d*) *Standing charges.*—These are necessarily reduced on account of the reduction in the capital expenditure, the number and size of the units, and the reduction in depreciation due to highly skilled supervision, etc.

(*e*) *Working expenses.*—In this case it is also clear that it does not take ten times the number of men to watch an engine of ten times the size of a small engine, and the same applies to boilers, pumps, etc. Secondly, the cost of management spread over the larger power-station is very much less. Thirdly, the larger the plant units and power-house generally, the more can be spent on labour-saving devices and economical auxiliaries, and therefore the smaller will be the consumption of local and other stores. Besides

this, as is well known, the larger the engine the more economical will it be in its consumption of steam, and therefore of fuel, etc.

These are all points so generally accepted that it seems unnecessary to enlarge on them ; but the following table may be of interest, and it leads to the next point which may not be so familiar :—

Capacity of station in kilowatts.	Cost per Unit. Load Factors.				
	60 %.	50 %.	25 %.	15 %.	10 %.
200	0·500	0·614	1·251	1·592	1·954
2,000	0·400	0·475	0·886	1·101	1·492
20,000	0·286	0·314	0·445	0·631	0·893
60,000	0·273	0·295	0·392	0·564	0·814

The above table shows clearly the economy of production in large stations as compared with smaller ones, and it also shows the influence of the load factor on the cost of generation. The figures of cost are based upon current English practice, and because of the smaller cost of coal on these coal-fields, and the greater cost of management and supervision compared with England, the differences of cost shown by the table, both those due to size of station and those due to the load factor, will be greatly accentuated. In other words the cost of generation in small stations and at low load factors will be considerably greater here than in England, while the cost of generation in large stations and at high load factors will be less than is shown by the table, owing to the greater influence of the load factor.

The load factor may be defined as the number of units which a plant (exclusive of spares) actually generates as compared with the number of units it is capable of generating during the same period, if working at full load throughout that period.

Now this load factor, on any station, is made up of the sum of the load factors on each machine connected to the mains, as controlled by the diversity factor of those machines.

For instance, to take haulages. Suppose that a haulage will be at work for, say, $7\frac{1}{2}$ minutes, lying idle for 6 minutes, and returning empties $4\frac{1}{2}$ minutes. Suppose, further, that it works for 12 hours out of the day. Its load factor, assuming that it works at full load when working at all, is therefore about 16 per cent. on an average working day. Now when a large number of such haulages are at work it will be found that as one starts up, another one shuts down. Thus the idle intervals on our power plant disappears, and, assuming a diversity factor 3, during the day of 24 hours a load factor of 50 per cent. in place of 16 per cent. would be attained.

The same thing applies equally, of course, to coal-cutting, winding, and other intermittent loads.

Now it is well known that it does not cost much more in coal and stores, and no more in wages and management, to keep a machine running at full load than it does at half load, and moreover any machine works very much better when the load is more or less steady than when it is constantly fluctuating over wide limits. It will therefore be equally manifest that the better the load factor the lower the cost of generating the power will become; and secondly, that the larger the number of intermittently working machines, whether haulages, lathes, tramcars, or any-

thing else, connected to the mains, the better will the load factor on the station become. Thus the large central power-station is able to generate its power at a much lower figure than the individual small station on a colliery can ever hope to do.

(*f*) Lastly, with regard to the advantages of the company there is the sixth point mentioned in the summary, *viz.*, that a power company is able to employ far more skilled management, supervision and labour than any one small station could afford to do.

This point needs little elucidation, because it is evident that when the cost of management, etc., is spread over a very large number of units it represents a very small amount per unit. Secondly, when the small individual stations are compared, and their aggregate cost of labour and supervision taken, it will be seen that there is a very large balance in favour of the central power-station. For instance, the staff that would have to be separately employed for the management of a colliery power-station of say 200 kilowatts exclusive of the cost of all time spent by members of the staff not solely engaged on the station, may be, say, Rs. 1,000 per month, or £800 per annum. If the same proportion were maintained for a power-station of 10,000 kilowatts, the cost of management staff would be £40,000 a year, which is of course absurd.

On the other hand, if the colliery power-station could afford to employ staff as skilled as that of a power company, the engines would not deteriorate so rapidly and their expenses, other than management, would certainly be less.

These facts and arguments show generally why it is that a power company can afford to sell their power at a price lower than that at which any individual colliery can generate, and it is now proposed to show the advantages

to be obtained by the collieries in buying power from a company.

(1) *Cheap Power.*—The table on page 107 has shown the cost of generation of electric power in stations of various capacities, and the cause of the variations has been explained. A power company can sell current to the collieries at prices varying from 1 anna to 6 pies, according to the load factor which the colliery actually gives, calculated on the actual maximum demand made by the colliery as compared with the total number of units used by them. Thus for a load of a more or less continuous nature, such as a pumping load, the cost will be 6 pies per unit, whereas for a very intermittent load, such as that provided by one haulage, the cost would be one anna per unit.

Now as the cost of current, should the colliery generate for themselves, would not be less than $1\frac{1}{2}$ annas and $2\frac{1}{2}$ annas respectively, it manifestly pays them not to do so, but to buy their current from a power company.

(2) *Freedom from Breakdown.*—This point also needs little amplification, as manifestly the colliery has far less fear of a breakdown when supplied from a large power company run with a highly paid staff and skilled labour, equipped with efficient and reliable machinery, provided with well-fitted repair shops, etc., than when running its own power-station with a necessarily lower paid staff, and comparatively unskilled attendance, no facilities for repairs etc.

The power company will, besides its power-station staff, have its distribution staff stationed at various points in the field to look after the lines, and its mine equipment staff, whose services are always available for breakdowns of motors, etc., in the mines.

(3) *Availability of Company's Staff.*—The power

company, besides the staff employed on the power-station and transmission lines, will also have a staff whose time will be entirely devoted to the inspection, maintenance and repair of motors and mining machinery generally; their services will also be available for the designing of extensions, and no charge for such services will be made by the company..

(4) *Repairs and Extensions.*—The company will have extensive workshops so that the repairs of motors and machinery can be undertaken on the coalfields and executed in the shortest possible time. They will also keep in stock a number of spare machines, pumps, etc., and all necessary spare parts. These spare machines will be available for extensions at any time, and will be also used in cases when a speedy repair of any breakdown is impossible.

As an instance of this may be mentioned the case when the come of water suddenly increases. All the manager has to do is to telephone to the company to send their engineer who will then arrange for the immediate installation of the necessary pumps to keep the workings open.

(5) *Responsibility.*—This is a point which should greatly appeal to a manager who is so familiar with the midnight call from the *khalasi* or fireman, and the occasional necessity for turning out on a wet night in the monsoon. To be able to exchange for this the use of a telephone to call up the central engineer will be greeted with approval, and the fact that the fireman will no longer be able to blow out his fusible plug to insure himself a comfortable night in bed will lift a considerable load of worry off the shoulders of the manager.

The fact that the telephone will be provided, and the engineer available, should gain assent to this point at once.

(6) *Reserve Power.*—The reserve of power in the central power-station will be only a small proportion of the whole amount of power, but in proportion to the demand of any one colliery it will be very large, and the fact that there is an enormous reserve of power, to meet any demands made on it, is an undeniable benefit which needs no amplification.

(7) *Labour Troubles.*—Present labour troubles will be considerably reduced for two reasons:—

Firstly, because the electric pumps will want no khalassies and the winding engines no fireman.

Secondly, because the machinery is of such a nature that it can easily be attended to and worked in case of necessity; or should it be wished to avoid this in an emergency there is always the power company's staff available at the other end of the telephone.

Under this head is also to be considered the loading of rakes. As a manager remarked during the recent cholera trouble, during the day it was too hot to load trucks, and at night it was too dark. With electric arc lamps on depots this will be changed, and night loading can go on quickly and safely.

Then again, coal-cutting, which is now being undertaken by hand labour only, can be done either by compressed air or electricity with ease and economy, and labour still further decreased.

The power company, in its anxiety to relieve the manager from all trouble, undertakes to provide the whole of the equipment of the mine, and to keep it in repair free of any other charge than an annual rental of 15 per cent. per annum.

This rental provides for a return of 5 per cent. on the capital involved, the remaining 10 per cent. being taken up

by depreciation and repairs. The interest has been fixed at the low rate of 5 per cent. because the Company is not doing this for a profit, but in order to :—

1. Obtain consumers.
2. Free the mining company's capital for mine development.
3. To standardise its machinery so as to facilitate repairs, etc.
4. To save the mining company the expense of keeping any spare parts.

The object of the power company is to sell power, and not to equip mines. The above proposition is therefore quite independent of the sale of power, and the colliery company is free to accept it or reject it as it may think fit. It will make no difference in the price of power. The work of equipment will be carried out by some contracting company to the instruction, and under the supervision, of the power company, and not by the power company itself; and should the mining company wish to do so, they can obtain competition tenders to the power company's specification from any other firms so as to ensure getting the lowest price.

USES OF ELECTRIC POWER.

To most people the uses of electric power are quite well known, but it has been thought advisable to add a few notes on this subject.

Pumping.—Electricity can be used to drive any form of pump, three-throw direct acting, or any other; but the most suitable is the turbine centrifugal pump. The latter will throw water to any height, runs at a high speed, and is very efficient, while the cost of repairs—a very heavy matter on most pumps, is almost negligible in this case.

Next to this pump, which is the one it is decided to adopt for most purposes, the most suitable is the three-throw pump, but its repairs will be much heavier. The Powell Duffryn Coal Company, in South Wales, has a turbine centrifugal pump which throws 1,350 gallons per minute to a height of 1,645 feet. The full load efficiency of the turbine centrifugal pump, when properly designed for the precise work for which it is used, approaches, and sometimes exceeds, 70 per cent.

Haulage.—Haulage is merely a matter of a motor coupled by gearing to a drum, and any system of haulage can be electrically driven with ease and simplicity.

On this point, however, one or two remarks may be made. The present tendency of the colliery companies is to design their haulage to draw a large number of tubs at a high speed, with the result that the haulage is capable of dealing, and does deal, with the total output of the mine in a very few hours, standing idle the rest of the day. This brings back again the question of the load factor. The cost of power will depend on the load factor, and the cost of equipment will depend on the maximum demand of power at each machine. Now a haulage designed in this way requires a large motor and heavy gear, and is expensive, whereas the same result could be obtained by hauling a much smaller number of tubs and working for a larger period. This would require a smaller motor and less expensive equipment, with a large load factor, and therefore less expensive power.

To raise an output of 2,000 tons per month from an incline, the best plant that can be advised would be a haulage machine designed to raise 100 tons in 12 hours, because 100 tons is likely to be pretty nearly the maximum of any one day in a month of 2,000 tons, and because

if the machine can raise the output by working steadily for 12 hours, there is plenty of reserve power for a considerable increase in the output. If the length of the incline is 2,000 feet, and the loads are hauled at a speed of three miles per hour, the mechanical equivalent of the work done in hauling up the coal, four tubs at a time, is as given in the next table for different gradients :—

One in	Horse-power equivalent of work done.
10	12
8	14
6	19
5	22
4	27

Winding.—The same remarks also apply here, as winding is only a vertical haulage. Here, again, a few special remarks are necessary as there is an impression among the colliery managers that electric winding does not pay.

That impression originated in the days when every mine had to instal its own equipment and power-station. Even in these days, under similar circumstances, it usually does not pay to put in electric winding, because the capital expenditure involved in installing power plant for machinery with such a poor load factor is so great in comparison to the return that no engineer who had been into the figures could honestly recommend it. Yet in this country the quantity of coal raised from any one shaft is so small that it is all done (or could all be done) in light loads

at low speeds. That means winding machines of comparatively small power, which would not cause such violent fluctuation in the load on the power-station as the enormously larger winding engines that have to be installed in Great Britain to wind a great weight of coal at a high speed from a great depth. With such small winding machines as the present pits require, it is possible that in many cases it would be advisable to instal electric winding machines even in connection with a separate colliery power-station.

This position, however, is entirely altered when the power is taken from a power company who supply not one, but a large number of winding plants, each certainly with a very bad load factor, but aggregating, in the total, to a reasonably good load factor. It is due to this good result of combination that a power company can afford to supply current for either winding or haulage at the extremely low rates already quoted. For the colliery the position is a simple one. Their power for winding will cost them, say, one anna a horse-power if bought from the company, whereas, if generated on the spot with steam boilers and a steam winding engine, it will certainly not cost less than three times this amount; and with the present machinery, in many cases, have in use more like eight or nine times this amount. The capital expenditure falls, of course, on the power company.

Coal-cutting.—There are several types of coal-cutters, but they may be roughly divided into five heads :—

1. Pneumatic percussion drills.
2. Pneumatic and electric wheel-cutters.
3. Do. do. chain-cutters.
4. Do. do. bar-cutters.
5. Electric drills.

The pneumatic percussion drills are used for heading work, as are also the electric drills, whereas the other three are designed and used chiefly for long-wall work, although they are also used for heading work. The air-compressors for the pneumatic drills and cutters are most profitably driven by an electric motor near the face. Each cutter will take about 15 to 25 H.P. to work, and the rate at which it will cut the coal depends of course on a number of factors. It is not proposed here to go into the comparative merits of the various types, as that phase of electrification would require a separate paper to itself. It may be said, however, that a number of mines intend to instal coal-cutters, and in several cases they propose experimenting with both types, as electric coal-cutters of recent design has not been tried on these fields.

Ventilating Fans.—The ventilation of most of the mines is at present accomplished by natural draught, but this will probably not be the case always; and as no more suitable or profitable load can be selected by a power company, the increase of mechanical ventilation will be welcomed.

Baling Pumps.—One feature of electric working will be the baling pumps, which will consist of small centrifugal pumps electrically driven and mounted on a small wheeled platform so that they can be taken from one working face to another, and used to pump the water at the face to the sump level from which it will be cleared by the dip pumps. These small pumps will expedite the driving considerably by making the conditions so much more comfortable for the miners and will do away with the need for employing labour for baling, always an unsatisfactory process at the best. This again will reduce labour troubles.

Lighting:—On this point, nothing need be said, as every one is familiar with electric lighting, and the

current will be available for it. Lighting both in the mine and at the depôt will considerably increase the convenience of working, and this ought to be reflected in an increase of output.

DISCUSSION.

The President moved a hearty vote of thanks to the joint authors, and, after it had been passed, declared the discussion open.

Mr. W. T. Griffiths referred to the absence of any reference in the paper to transmission, and mentioned the uncertainty of transmission, in previous electric schemes of central power stations. As an example, the South Wales plant might be mentioned. There, owing to the failure of the lines, by which power was at times cut off for as much as a week, the Powell Duffryn and another large colliery were compelled to put up their own plant. Unless there were alternative transmission lines, so that one could be utilised in case of failure of the other, such succession would occur in the future.

Mr. W. A. Lee, in reply to Mr. H. G. Graves, stated that alternating current of 50 periods per second would be used. He also informed Mr. G. F. Adams that it was proposed to have a separate station in each coal-field.

Mr. T. D. LaTouche asked if the electric plant which they had recently seen at Sodepore was efficient and remunerative.

Mr. Glen George announced that practically the Sodepore station was successful, but at present details of the cost could not be given, as the plant had only been in operation for about a year.

Mr. W. A. Lee replied to the discussion. The existence of a central power station depends on the continuity of its supply, so that alternative routes of conductors were absolutely necessary. They proposed such a network that more than one path would be available. If one company, and especially if it was a large one, withdrew its custom, the price per unit had to be raised to all the rest. It was even more to the interest of the power company than of the consumer that there should be no interruption, and that the reliability of the supply should be unquestionable. Very careful consideration had been given to the coal-fields transmission lines, so as to ensure, as far as is humanly practicable, that there should be no chance of even a temporary failure of supply. Overhead conductors were a necessity. The withdrawal of certain South Wales companies was caused by the failures in the underground mains on which insistence was first laid.

The President in postponing the discussion avowed that he was greatly in favour of the power scheme.

The following paper was then read by Mr. Pitt.

An Ignition of Coal Dust.

BY

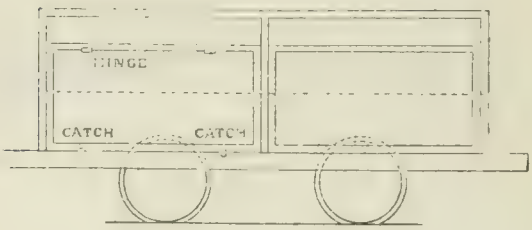
G. N. A. Pitt.

In writing the following account it is the author's desire to draw attention to an undoubtedly great danger in Indian coal mines.

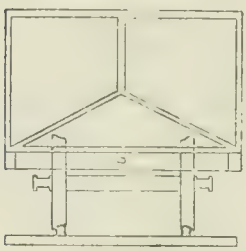
So far, Indian mining engineers have not generally been much troubled by firedamp, and therefore, up to recently, explosions in coal mines have fortunately not been of frequent occurrence; but there is another danger which at one time was quite unsuspected, *viz.*, coal-dust alone. Even when explosions did occur, it was taken for granted that a small amount of firedamp must be present. Later, blown-out shots were included as igniters of coal-dust, and now many causes may be named which will raise and fire a cloud of dust in a dry and dusty mine. The following occurrence, which was witnessed by the author, will show that under certain conditions Indian coal, in a finely divided state in the atmosphere, forms a highly inflammable mixture; and had the following occurred in a confined space, there would no doubt have been a violent concussion.

At 2 P.M., on the 23rd of March, 1908, at the Bengal Coal Co.'s Kuldeah Collieries, Giridih, the following took place. A wagon (or trajector) of dust-coal had been shunted to the No. 31 Pit for the boiler fires. The construction of the wagon will be observed by reference to plate below. It will be noticed that the wagon (which holds about $2\frac{3}{4}$ tons of dust-coal, *i.e.*, small unscreened coal) has a hoppered bottom—the slope being from the centre towards

SIDE VIEW



END VIEW



the sides—which are fitted with doors having hinges at the top, so that when the catches, which hold the doors in their places, are released, the weight of the material forces the doors open and the wagon thus empties itself. Now, at the time as above stated, a wagon of this description loaded with dust-coal was shunted by the locomotive to a point from which kamins, or women coolies, carry the coal to a range of boilers. This point is on the top of an embankment about 20 feet higher than the surrounding ground. A moderately strong breeze was blowing at the time in a direction across the line so that when the coal dropped from the wagon a large cloud of dust arose which was carried along by the wind away from the wagon. Immediately this cloud was formed it burst into flame; the author was on the footplate of the locomotive at the time and felt the intense heat, though the flame only lasted

about 20 seconds. After the flame died out an examination was made to ascertain the cause of the ignition. The only fire about at the time was on the locomotive, but there were two red-hot pieces of "clinker," each about the size of a hen's egg, which had evidently just fallen from the ash-box of the loco, and they were lying between the rails just under the end of the wagon. It would seem that some of the dust had been blown on to these clinkers and burst into flame, which in its turn fired the cloud of dust. The coal had been gathered from the siding at the 29A Pit, and had probably been accumulating for some weeks. It was very dry, having been exposed to the sun whilst lying there; and as it had been loaded during the middle of the morning it therefore had every opportunity of becoming perfectly dry. The dust was from the Karharbari main seam coal which is being worked at a depth of 400 feet at these collieries. The mine workings are not what would be called "dry and dusty" but still are not wet.

Analysis of the Dust-coal.

	Coal-dust rom surface sidings.	Coal-dust from the pit roadways.
Moisture	·20	·40
Volatile matter (combined)	25·95	25·30
Carbon (fixed)	61·025	60·20
Ash	12·825	14·10
	100·00	100·00

The foregoing is another link in the chain of evidence proving that an ignition (which in a coal mine would be an explosion) of coal-dust can occur without the aid of fire-

damp or blown-out shots. Other ignitions of coal-dust without the presence of firedamp are on record. In Vol. xxxiv, part 2, of the "Transactions of the Institute of Mining Engineers," on p. 221, an account is given of an ignition of coal dust in the Beeston seam at the Middleton Collieries near Leeds, England; the igniting flame being an open safety lamp, the dust having been raised by a passing train of coal tubs drawn by a pony. On page 229 an account is given by Mr. W. Walker, an Inspector of Mines for the Yorkshire and Lincolnshire District, of an experience he had at Brancepeth Collieries in Durham in the year 1889. This was in connection with the cleaning of a coal hopper; he says: "Six men were sent to clean out the hopper, three going to the top and three to the bottom of it. It was a large hopper, measuring $24 \times 31 \times 36$ feet; in the inside of it there were four stages, and the whole arrangement was held together by iron tie-rods from side to side. Open torch-lamps were used, and were hung near the bottom on the tie-rods. The men on the top had not been brushing the dust down for more than two minutes when there was a violent explosion, the three men at the top being killed, and those at the bottom injured.

There could not, in that case, have been the smallest trace of gas present, because the top was fairly open and the ignition took place at the bottom of the hopper.

There is another more recent account of an ignition of coal-dust by a naked light. In "Mines and Minerals," 1907, vol. xxviii, page 161, the following appears: "On Thursday, September 12th, there occurred at mine No. 10 of the Union Pacific Coal Company, Rock Springs, Wyoming, an explosion of dust, which in its cause and effects is unique in the annals of coal-mining accidents. It occurred at about 5 o'clock in the afternoon when the miners were

preparing to leave the mine. About forty of the mine workers had gathered at the foot of the slope (which is an intake air-way driven 1,000 feet at an inclination of 20 degrees), when a trip of empties was started from the top. The coupling between two of the cars had not been properly made, and when the trip reached the head of the slope, six of the cars started down the incline unchecked. By the time they had reached the bottom they had acquired a terrific speed and collided with a trip of full cars waiting to be hoisted. Fortunately the men had gotten out of the way, but the impact created a great cloud of dust, raised principally from the floor of the gangway, and this dust was ignited by the lamps of the miners. It appears that the mixture of dust and air was not of a character to produce a violent explosion. There was, however, an instantaneous combustion, which produced sufficient heat to burn more or less seriously every man in the immediate vicinity, but none of them so badly that he was not able to walk or crawl out of the man-way. The force of the explosion was felt more seriously 200 or 300 feet down the gangway, and there a miner was thrown violently down and sustained a broken arm and other injuries. One of the peculiar and fortunate effects of the explosion was the partial wrecking of an overcast a short distance east of the slope. This resulted in the short circuiting of the air-current, which carried off the products of combustion and prevented any deaths from suffocation.

In an extract from the report of M. Delafond, Inspector-General of Mines in France, on the Courrieres disaster, which appeared in the *Colliery Guardian* of the 16th of August, 1907, it is stated: "That as regards the coal-dust danger, neither the experiments made nor the teachings of practice permitted them to suspect the possi-

bilities in a non-firedamp mine, of an inflammation of such dimensions, the explosions of coal-dust alone, in the absence of firedamp, hitherto registered in France, having never extended beyond distances of from 50 to 80 metres from their point of origin, with the single exception of 180 metres in Decuze Mine in the accident of February 18th, 1890. So that the dispositions taken, open to criticism as they may be now owing to the consequences they have had, could not be incriminated before the catastrophe. With regard to the lessons to be drawn, the Council recommend that henceforth the same measures of security should be adopted in all mines as were observed in mines containing firedamp. That naked lights should be abolished, and the exclusive use of safety explosives, with ignition by special *bonte-feux*, ordered."

It is hoped that these notes may be the means of bringing more light on the subject, and that precautions may be taken before any terrible calamity occurs. The author shares with many people the opinion that coal-dust in the mine is a very great danger. There are so many causes which may raise the dust such as blown-out shots, ignitions of firedamp, run-away tubs, trains of tubs in course of haulage, falls of coal in pillar-working, and goaf blasts. Any one of these might raise up a cloud of dust; and if it happened to be ignited there would be no telling what the result might be.

The Indian Mines Act has no rule bearing on coal-dust with the exception of Rule 13 (*g*): "In any place which is dry and dusty, or in which the use of a locked safety lamp is for the time being required by or in pursuance of these rules, no shot shall be fired, except by and under the direction of a competent person appointed by the manager of the mine.

The author wishes to express his thanks to Mr. T. H. Ward, Superintendent of the East Indian Railway Company's collieries, for having made the analyses of the samples of coal-dust.

DISCUSSION.

The President, after offering the thanks of the meeting to the author, stated that the paper was of considerable interest to the mining community which had not yet taken much interest in dust.

Mr. J. R. R. Wilson, Chief Inspector of Mines, desired to obtain the opinions of Indian colliery managers on the coal-dust question generally, and thought that this paper should afford a good opportunity. The dryness of Indian collieries was one of the first things that struck him when he came to this country. In the dead ends especially, large quantities of very fine dust settled and might give very bad results in the case of blown-out shots. It took very little to originate a dust explosion. He had just come down from Khost in Baluchistan where there had been a very serious explosion that, without doubt, was a dust explosion, though some gas had in all probability been the originating cause. The dust there was very fine, and dangerous, the proportion of hydrocarbons in the coal being very great, as he had proved by experiment, and he had brought samples with him.

Mr. C. H. McCale read the following note :—

During a period of over 160 years, the subject of colliery explosions had engaged attention, and several expert mining engineers had addressed themselves of the elucidation of the cause. The fact of firedamp, CH_3, being present in the mine and ignited by an exposed flame,

naturally left no other method than to remove the gas to prevent explosions.

It was not until after the first three safety lamps had been invented by Sir Humphrey Davy, Dr. Clanny, and George Stevenson, and a better system of nursing the air round the mine introduced, that mine explosions occurred with much less frequency. But, as time went on, the mines were developed on a larger scale with a consequent increased number of workers, and although explosions occurred with much less frequency, they were more disastrous when they did occur, as twice and sometimes more in number of lives would be lost.

As far back as the year 1806, Mr. John Buddle is said to have suggested that when firedamp was locally ignited, such as by a defective safety lamp or by the flame passing through the gauze of a safety lamp or by an open light, which were then considered the chief causes of gas explosions, coal dust would increase and extend the explosion.

In the year 1812 an explosion occurred at Felling Colliery, and the Rev. John Hodgson called attention to the large quantities of coal dust ejected from two shafts, one discharge from one shaft and two discharges from the other shaft.

Again, in the year 1845, with reference to an explosion which occurred at Haswell Colliery, Messrs. Lyell and Faraday were the next to bring to notice, and corroborated Mr. Buddle's statement, that coal dust was a factor in explosions. After the Haswell Colliery explosion, coal dust was found to be in a friable coked state. Several other explosions have since occurred in mines where firedamp was never found, and particles of coked coal dust after the explosion has been most conspicuous. This, together with recent experiments, have conclusively proved that

coal dust has played the most prominent part in the explosion; and attention, consequently, has been given to a considerable measure of success to avert this inherent danger of coal dust in mines.

The existence of coked coal dust after an explosion tends to prove that the volatile matter constituent of coal dust is the chief cause of the rapid ignition that makes coal dust in air explosive.

After coal dust has been heated above F. 212° inflammable gas is liberated from the dust. As the temperature of the dust rises the liberation of gas, in the form of little jets, is rapidly increased, and finally the surrounding air and the gas emitted forms an explosive mixture. Professor Bedson has proved that fine coal dust will ignite at a temperature of F. 291°, provided this heat is continuous for some time. Sir Frederick Abel states that 2 to $2\frac{1}{2}$ per cent. of firedamp is required to form an explosive mixture with air and coal dust.

Professor Galloway, to whom the mining community are much indebted for the present dust theory, states that even 1 per cent. of firedamp is sufficient to form an explosive mixture with coal dust and air. He also states, that 1 lb. of coal dust mixed with 160 cubic feet of air is an inflammable mixture.

Mr. Robert Scott, Secretary of the Council of Meteorological Office, made a series of experiments which demonstrated how seriously the coal dust adds to the force of an explosion. Mr. Scott concluded from his experiments that where there is no coal dust in the gallery, the flame of the firedamp explosion does not extend further than from seven to nine feet from the bottom of the explosion chamber with which he experimented. When the gallery contains coal dust, on the other hand, on the floor and

sides, and when it is filled with the return air of the mine, the explosion traverses its whole length, and shoots out into the air to distances varying from four to fifteen feet. The flame of the firedamp explosion is thus magnified ten times by the presence of the coal dust in the return air.

Before coal dust will inflame it must be in a very fine and dry state, and it would appear that the hopper of dust referred to by Mr. Pitt possessed these qualities. But at the same time I am inclined to think that the two clinkers must have fallen when in a state of flame upon very fine and dry coal dust which had possibly accumulated on the ground at that particular place, which would set the dust ablaze and extend the flame to the cloud of fine and dry dust which was blowing in the direction away from the hopper or wagon when it was being discharged. There would seem to be a non-sufficient supply of fine and dry dust, otherwise there would have been a probability of the flame extending right up and into the wagon. Perhaps, Mr. Pitt may be able to inform us, whether he noticed any coked coal dust as a result of the ignition when he made the inspection.

Owing to the damp weather it was not possible to perform a few experiments even on a small scale, of course, with coal dust from different seams of coal now worked in the Ranigunge Coalfield. However, a further series of experiments may be made at some time in the near future ; it will, no doubt, be of interest to the members of the Institute to learn the results.

The tin case by which the experiments were performed was one foot long, six inches deep, and six inches wide; and the analysis of dust used for two experiments was as follows :—

Sample 1—

Carbon (Fixed)	.. ..	56·30 per cent.
Volatile Matter (Combined)	..	33·55 ,,
Ash	..	9·90 ,,
Moisture	..	0·25 ,,
		100·00 per cent.

Sample 2—

Carbon (Fixed)	.. ..	56·15 per cent.
Volatile Matter (Combined)	..	32·65 ,,
Ash	..	11·00 ,,
Moisture	..	00·20 ,,
		100·00 per cent.

Sample 1 is dust from the Sanctoria seam, collected from around the bottom of coal pillars, which had been crushed off the pillars owing to thrust; and Sample 2 is dust from the Dishergarh seam and collected from the bottom of coal pillars as in Sample 1. The both samples of dust was very fine and dry and of a brownish colour.

One and a half ounces of Sample 1 was placed in the tin case at one end and a small open lighted lamp at the other end. At the end where the dust was placed a cycle tube valve was fitted, and by the aid of a cycle inflator the dust was raised into a cloud right over the open light and the dust ignited and blown off the cover of the tin case. This experiment was repeated, and on each occasion the dust did not fail to ignite and force off the cover of the tin case. But when only one ounce of dust was placed in the case it would not ignite.

When $1\frac{1}{4}$ ounces of Sample 2 was used for experiment it would ignite and invariably raised the cover off the case; but when one ounce only was used it would not inflame.

From these results it is proved that it is absolutely

necessary for certain quantities of different classes of coal dust to be mixed with air before it will inflame when exposed to an open light.

At present it is not thought there is cause for much alarm as regards the presence of inflammable coal dust in Indian mines, but the experience of this very deadly enemy has been dearly bought, and it therefore behoves the manager to take the greatest precautions and rigorously observe this serious and ever-present danger, keeping in memory the old proverb: "A stitch in time saves nine."

In reply to a question by Mr. G. F. Adams, he said that the dust samples were collected and tested on the same day during May.

Mr. R. R. Simpson said that the author in his paper has quoted an interesting case of an explosion due to the ignition by an open light of a cloud of dust raised by the wind consequent on a collision of runaway mine cars on a haulage slope. In this instance several persons were burnt, but no great damage was done. A similar cause has been assigned for the disastrous explosion at the Monongah Collieries in West Virginia early in the present year, when several hundreds of persons lost their lives, and enormous damage to property resulted. Just before the explosion took place a trip of mine cars ran away down a haulage slope, and near the bottom they wrecked the electric cables. It is presumed that the sparking, which would naturally result, ignited the inevitable dust cloud and initiated the explosion.

The danger from coal-dust in India is more apparent in the dry and dusty coal mines of the Central Provinces than in the collieries of Bengal. As mechanical coal-cutting comes more into use, and as a consequence blasting

becomes more general, the danger from coal-dust is likely to increase. It may be remarked, however, that nearly half a million tons of coal are produced annually entirely by blasting at the Singareni Collieries in Hyderabad, and as far as he was aware, no ignitions of dust have been recorded.

Mr. Glen George said that the question primarily at issue was whether coal-dust under the conditions met with in Indian mines was likely to lead to an explosion or not. That coal-dust, under certain conditions, was a very great danger was universally admitted. In neither of the instances given by Mr. Pitt or Mr. McCale did the conditions approximate to those in the mine. Under present conditions there is little probability of coal-dust explosions in Indian mines.

Mr. E. H. Roberton remarked that the most striking point in Mr. Pitt's paper was that he had given an example of ignition of coal-dust without the presence of gas, and merely by means of a piece of hot clinker, which is comparatively a very cool igniting agent. He mentioned the Prussian Coal-Dust Commission, by which experiments were carried out on a most elaborate and comprehensive scale, and which up to now was the most important authority on the subject. The most dangerous dust is that containing from 20 to 27 per cent. of volatile hydrocarbons. Lower than 20 per cent. and higher than 27 per cent. there was a marked falling-off in the facility of ignition. He noticed that Mr. Pitt's sample, containing 25 per cent., came within these limits. It was found to be the rule that 2 per cent. of firedamp in conjunction with coal-dust was violently explosive. In the ordinary miner's

lamp 2 per cent. of firedamp is quite indistinguishable, and no doubt many explosions have taken place in which the officials were quite positive that there was no gas in the mine, whereas there may have been the requisite 2 per cent. in several places. In lignite mines, where there is as a rule a great deal of inflammable dust, but very rarely firedamp, a coal-dust explosion is almost unknown.

Mr. J. R. R. Wilson observed that knowledge had advanced since the days of the Prussian Commission, and it was now universally admitted that coal-dust clouds, under certain conditions, would explode in the presence of open lights whether gas was present or not.

Mr. W. T. Griffiths stated that open lights often did not explode coal-dust. The conditions under which they would, and they would not, were as yet somewhat obscure. There were many dusty pit bottoms and enclosed screening plants in which the air was as dusty as possible; yet flaring naked lights were used there without evil results. He called for experiments.

The President remarked that dust was very prevalent in many mines, and was undoubtedly a latent source of danger that might make itself felt at any time. Mr. Pitt's paper was exceedingly useful in that it called attention to the whole subject. He hoped that, by postponing the discussion, they might obtain further views.

The author promised to reply in writing, and the following paper was then read:—

Longwall Method of Working Coal at the Seeterampore Coal Company's Collieries, Nursamooda.

BY

Willis Howarth.

Some time ago a paper was read before this Institute on the Wastage in Bengal Coal Mining. The author in his excellent paper, for certain reasons, did not deal with what actually may be described as the main cause of such wastage—the system of extracting the coal. This want of a proper system is more noticeable in collieries owned by natives.

In deciding the method of working a seam of coal in order to get the best results at a minimum of anxiety, the mining engineers of India, like all the mining engineers in Europe, must be guided in the selection of the system of working by three conditions which may be defined as follows:—

1. The Physical Conditions of the locality.
2. The Human Conditions.
3. The Mechanical Conditions.

1. PHYSICAL CONDITIONS AT NURSAMOODA.

The Seeterampore Coal Company's Collieries lie north-west of Asansol on the Grand Trunk Road, between the

miles 139 and 140½. The property itself is rich in its mineral wealth, all the known seams of coal in the district, from the Nursamooda seam to the Dishergarh seam, lying within a workable depth.

Only the Nursamooda seam is at present being worked. It outcrops at about the 140¼ mile-post on the Grand Trunk Road, running approximately N. 67°30′ E., the rate of dip being 6° or 1 in 10, dipping S. 32° E. The overlying strata are alternating beds of sandstone of various colours and texture, with a dark shale bind about 2 ft. 6 in. in thickness; this bind thickens to about 25 ft. to dip at 1900 ft. from No. 3 pit. A dyke runs through the property at S. 40° West, the approximate width being 40 ft., but it has not yet been proved by any drifts. There are several slip faults in the property, running parallel to the dyke, but none of them fault the seam more than 4 ft. The faults are mostly on the west side of the dyke.

The No. 3 pit is sunk down to a depth of 150 ft., the seam at this point being 3 ft. 9 in. thick with 1 ft. 3 in. of shaly coal at the roof forming a strong bind against about 6 ft. of shales to the sandstone. The coal is a good steam raiser, and compact, the cleats being well defined. Fig. I., shows a section.

The seam previous to March 1907 had been worked by a modification of bord and pillar. Headings were driven on the strike of the seam 10 ft. wide, every 20 ft. being cut through by a bord 10 ft. wide, thus dividing the coal into square blocks of 20 ft. by 20 ft. By this method only 44·4 per cent. was worked on the first winning.

When the boundary was reached, these pillars were further reduced by cutting them into small pillars which were afterwards left in to support the roof, thereby

increasing the final winning to 61·5 per cent. or an increase of 17·1 per cent. on the first working. The method is illustrated in Fig. II.

Change in System of working at No. 3 pit.

As previously stated in March 1907, the management came to the saving knowledge of the truth that, at the rate at which they were working their seam of coal, which is so thin as compared with the coal seams in general of Bengal, in order to maintain their output more shafts would very shortly have to be sunk to the dip. That course, it is needless to say, is most undesirable, except in cases of absolute necessity. It was therefore decided that something had to be done in order to maintain or increase the output, with a reduction of the area worked. Nothing seemed to present itself under the existing conditions as a remedy except a change in system of working, and the adoption of modern ideas of winning coal.

After carefully inspecting the colliery, the character of the coal, its roof and sill, the information regarding the roof being obtained from falls of old wastes, it was decided to try longwall as an experiment. A face was marked off in such a position that in case of failure from any cause, that part of the mine would not be ruined, but could be worked by reverting to the pillar system again, and the output not interfered with.

Setting off the Longwall Face.

The working face was originally 180 ft. long in virgin coal. This length was divided into two equal lengths of 90 ft. from centre to centre which were called banks, and were numbered 1, 2, respectively. Miners were set to

work in each length of face, and the raising went up directly from one and two tubs per day per man, to five and six per man in some cases. The face advanced rapidly for a time, and rows of timbers 4 to 6 in. in diameter were set systematically at equal distances of 3 ft. 6 in. with chocks made up of square timbers 4 in. by 4 in. by 2 ft. 6 in set about every 15 ft. The chocks were built upon loose dust so as to aid in their easy extraction when required to be withdrawn in order to be put nearer to the working face. As the face advanced to 15 ft. packwalls were built on each side of the centre of the bank gate, leaving a gateway 6 ft. wide. The packs were put on 10 ft. wide. These walls were at first built by debris procured from cleaning the tramways, for which was paid two annas per running foot for each pack. For height in the gateways 18 in. of the bottom was cut up and thrown into the packs; this was also paid at the rate of two annas a running foot. The cost for packing and floor cutting combined was six annas per running foot for each gateway.

As the face advanced further it became necessary to support the roof by packwalls down the centre of the banks, thus allowing for one bank to have a face 45 ft. on the right and 45 ft. on the left side with chocks as extra support between each pack. This radical change was costing money, so it was agreed by the management and men that one anna per tub should be taken off the price. By this reduction it was thought that there would be a little surplus in order to meet any further contingencies, such as extra supervision, etc. But after three months' experiment it was found that the cost of production was actually more than in the old system, and that was attributed to the fluctuation of the labour.

Cost of working from March 19th to June 15th.

	Longwall.	Bord and Pillar.
Shifts worked on face, number ..	526	1687
Steam coal produced, tons ..	758	2,229
Average per man, tons ..	1·4	1·3
Rate ..	4 as. 3 pies.	5 as.
Dust produced, tons ..	44	500
Average per man, tons ..	0·08	0·29
Cost of packing per foot ..	Rs 35 15 6	..
Cost of bottom cutting ..	Rs. 26/10/0	..
Cost of timber, extra ..	*Nil.*	..
Average cost per ton ..	annas 11	10

From the above table of the comparison in cost of production, it will be seen, that by the change in system one anna more per ton was being paid. But there was the satisfaction in seeing a great reduction in the production of small coal and dust from 0·29 tons per man, to 0·08 tons per man per day. This was considered a great advantage, and was one of the main points that was held in view, as the greatest wastage in a bad system of working coal is the amount of dust that is accumulated around the pillars, and is either buried by a fall of roof, or is cut off by a fall. The dust, that is allowed to remain, gives rise to a most undesirable state of things in a mine, especially in mines liable to spontaneous combustion.

The experience gained by the ten weeks change in system did not appear to give too gratifying a result, seeing that the average increased output per man, when comparing the systems, was only 0·1 tons. Yet it was deemed satisfactory enough to give the system a thorough trial and also to extend it as far as practicable in the other collieries; but a difficulty arose in those collieries and the system has not yet progressed as much as was desired. The reasons are dealt with later.

When the working face had advanced to the dip some 150 feet, it was decided to stop it and work on the rise, or

N. and S., owing to the difficulty of keeping the face straight, and to the fact that it was not advancing quickly enough. Further the roof was giving indications of unequal weight, threatening to break over the face. The packwalls were made tight and brought within six feet of the face to form an airway to the north and south face, this face being at the time 150 ft. long. It was found that the miners liked the new face much better and they worked more regularly, the water not lying on them as was the case with the dip face. The north and south face is carried on packs about 15 ft. from centre to centre. Practically the goaf is stowed completely. Although this method of packing has its advantages, it also has its disadvantages, especially at Nursamooda colliery, where the scarcity of building material from the roads and the want of more packwallers is somewhat severely felt. Yet it has been done in order to maintain the face in a perfect condition for further developments by mechanical means.

Since the management decided upon working No. 3 pit by longwall the system has now been under experiment or 12 months with a certain degree of success from the local point of view. The coal has been completely extracted as shaded in the plan, Fig. III. In the annual survey of No. 3 pit for the year 1907, 15 per cent. was written off as wastage in working and dust against 20 per cent. wastage in working and dust in 1906. Thus there was a saving of 5 per cent in this item alone, and the raisings in 1907 exceeding those of 1906. From this alone it is proved without doubt that longwall working is the most economical method of working a seam like the Nursamooda.

The schedule shows the comparative cost of working approximately only by giving the actual cost of getting,

etc., the haulage, and supervision being ignored. The cost of bord and pillar being 1-0-4 against the longwall 0-15-8 per ton, it will be seen that the average output per shift per man for longwall was 1·37 tons against the bord and pillar 1·2 tons. The amount of dust and rubble coal raised was 2815 tons; the relative average of each is not included, owing to the exact amount in each system not being kept separate. By working with the longwall system, there is a decided advantage in the supervision and the laying out of the labour. Also it requires no main drivings to be at work to make room for the miners; whereas in the bord and pillar system, to give working space to the same number of miners as the longwall, two main headings have to be driven at the rate of 15 to 20 feet per week each. That means a cost of about Rs. 40 per week. It will be seen from the Schedule, that for 8351 tons raised it cost Rs. 853-4 for drivings alone, or an average 0-1-6 per ton raised.

Statement of cost of Longwall working from 15th June 1907 to 31st May 1908.

Date.	No. of shifts worked.	Total output.	Cost per ton.	Average tons per shift per m.	Packwall floor cutting and other work on the face.	Timber account.	Average cost per ton.
1907		Tons.	A. P.	Tons	Rs A. P.	Rs.	Rs. A. P.
June 15th, 30th..	78	94	12 1		12 14 6		
July ..	188	213·5	,,		26 11 3		
Aug. ..	289	403·5	,,		25 10 3		
Sept. ..	236	321·5	,,		38 10 6		
Oct. ..	280	324	,,		30 7 3		
Nov. ..	392	395·5	,,		33 3 9		
Dec. ..	764	1,015	,,		58 13 0		
Jan. 1908 ..	370	471	,,		34 0 6		
Feb. ..	540	614	,,		77 1 6		
Mar. ..	301	793	,,		93 7 0		
Apl. ..	459	574	,,		37 7 0		
May ..	234	781	,,		60 15 6		
Surplus Coal. ..	..	741	,,		..	150	
	4121	5,680	12 1	1 37	529 6 0	150	0 15 8

Statement of Bord and Pillar system for the same period.

No. of shifts.	Total output.	Cost per ton.	Average tons per shift.	Cost of Main Headings.	Cost of Bottom Cutting.	Other work on face.	Timber account.	Average cost per ton.
	Tons.	A. P.	Ton	Rs. A.	Rs. A.	Rs.	Rs.	Rs. A. P
366	385·5	14 0		24 12	10 0			
1019	1,040·5	,,		..	..			
861	894·5	,,		47 4	34 8			
947	872·5	,,		41 4	18 4			
924	835	,,		101 4	58 7			
323	727·5	,,		70 8	35 12			
320	276·5	,,		81 12	..			
701	652·5	,,		73 0	23 12			
699	868	,,		50 4	15 0			
220	261	,,		30 12	14 12			
137	134	,,		58 0	16 8			
383	214	,,		28 8	19 8			
..	1,091	,,		..	..	240	80	
6900	8,351	14 0	1·21	607 4	246 7	240	80	1 0 4

2. THE HUMAN CONDITIONS OF LONGWALL WORKING.

Questions of native labour are perhaps the most important part of the subject when contemplating a change in the system as a whole or, indeed, even when any little variation is made from the usual way of things. The difficulties which arise are not quite so easily overcome in most cases as one might think, and they are the determining factors in the successful adoption of longwall working. First and foremost native prejudice has to be overcome, and it needs all the tact and skill and perseverance that a manager can bring to bear. I have often wondered what a mining engineer at home would do, if some morning, when he arrived at the colliery, a deputation of milkmen, shoemakers and farm labourers met him and wanted a job of coal cutting. I fancy he would stare and exclaim, "From all trials and temptations of this wicked world, Good Lord, deliver me!" Here in India we never ask them whether they have or can cut coal, but we welcome them with sweetest smiles, not even asking for a character.

This native element was very soon encountered. After the face had gone some 30 ft., the timbers had been left in a little way back in the goaf, more than was desirable, in order to establish confidence amongst the men. But it speedily became absolutely necessary to withdraw the timber, as it is impossible to sustain the roof of a longwall face with timber. When intimation was given of this intention the miners were up in arms and objected to any such thing being done; they had never seen it done before, and they were not going to have it. But we had and were going to do it, so we withdrew the timber during the interval of changing shifts, and had the satisfaction of hearing

the roof fall in its appointed place along the face, and seeing the face retimbered before the miners returned.

This system of withdrawing the timber is carried out daily and there has been no trouble since, the roof coming down very regularly, and the miners have got used to the method. Now the older miners say they would rather work on the longwall face than in the bords and pillars. They earn more, work shorter hours, and are much cooler than in the blind ends of the old system. What is more to the point from the miners' view is that he does not have to leave his own place in order to have a chat or smoke with a chum, a fertile source of waste of time. In order to teach new recruits, who are obtained from the Central Provinces, how to get used to the work, they are put with a few old miners in the pillar workings. The old pillars are taken out in one line as in longwall, but instead of the goaf following the miners, they work towards the goaf with their backs to the solid pillar. As the pillars are being cut away in line the timber is set systematically as in longwall. When the line of pillars is finished, the miners are put in between the next row of pillars to be taken out and the timber is removed from the goaf. As the roof falls immediately by this method we are able to train the miner to work on the longwall face, he having previously got used to having timber set behind him; also he seems to have got his nerves when he hears the roof falling in the back goaf.

3. THE MECHANICAL CONDITIONS.

As it will be seen from the second trial of 12 months given in the schedule, taking all conditions and comparing them with the old system, longwall working has proved satisfactory. The management accordingly decided to try

mechanical coal-cutters, so that the output would be steadier, and not so spasmodic as is the case when native labour is employed. As the machinery has not been erected yet, only a description of the plant and the necessary developments above and below ground can be given.

A compressed air plant is being put down at No. 3 pit for generating power to run one machine and the pumps. The steam cylinders are 24 in. in diameter with 24 in. air cylinders and were supplied by Messrs. Walker Bros., Wigan. The plant will only be single for a time, but the duplication can be brought out any time it may be thought necessary.

The receiver at the surface is a 30 by 7 ft. Lancashire boiler, and the air is being carried down the shaft in 6 in. pipes, specially made with patent packing for the joints. The pipes were also supplied by Messrs. Walker Bros

The receiver under ground is an eleven-foot cylinder 3 ft. 6 in. in diameter. It is placed near to the face, and from it the air will be led by 2 in. pipes to the coal-cutter which will require about 700 cu. ft. per minute at 45 lbs. pressure.

The cutter is supplied by the Diamond Coal Cutter Co , Ltd., Wakefield, this machine being the first of its kind in Bengal. Cylinders 8 in. stroke $8\frac{1}{2}$ in. cutting 5 ft. 6 in. under the coal With this machine it is expected that the output will be increased by 4,000 tons monthly in No. 3 pit.

On the duplication of this plant it is estimated to generate 3,500 cu. ft. of free air per minute, at a pressure of 60 lbs. at the receiver, sufficient to work 4 cutters.

DISCUSSION.

The President, in opening the discussion, briefly reviewed the history of longwall working in India and

thought it was the coming system. Patience and perseverance would overcome the labour difficulties as had been the case at Nursamooda, and the cost would decrease as the system extended. After offering a vote of thanks for the paper he called for further discussion.

Mr. Wilson had seen the longwall face in question and thought that it would be described in Yorkshire parlance as "very tidy." He asked whether there had been a real weight on it and remarked that regulating the weight was one of the elements of success in longwall working.

Mr. Howarth replied that the pack walls had settled down to a thickness of about 2 feet, and the goaf had come down nicely and uniformly between them.

Mr. W. Forster had tried the longwall system some years ago at Sitarampore and was successful, but had to stop it because the miners got afraid when falls of roof took place in the goaf.

Mr. Pitt asked about the timbering at the longwall face, the cost of ripping, and the method of supporting the gate ends.

Mr. Howarth replied that timber props were set diagonally at 3 ft. 6 in. centre to centre. The cost of ripping was the same in both longwall and in bord and pillar workings.

The President postponed the discussion and stated that by desire of the author a paper by Mr. W. T. Griffiths on Mine Dams would be taken as read. A vote of thanks for

the use of the Club, and the efforts of Mr. Horace Chambers in arranging details and providing breakfast, was proposed by Mr. H. C. Veasey and passed. Also, on the motion of Mr. B. Heaton, the thanks of the Meeting were tendered to the President. The proceedings were then closed, and the members adjourned for a short while so that the room could be cleared for breakfast.

Mine Dams.

BY

W. T. Griffiths, A.R.S.M., F.G.S.

Some of the chief uses of dams in mines are :—

1. To conduct the ventilating current.
2. To shut off areas on fire or old workings.
3. To keep back large bodies of water.

They may be necessary for temporary or permanent purposes, and the rapidity with which they can be erected, is sometimes of the utmost importance in cases of fire.

In ventilating non-fiery mines worked by a pillar and stall system, it will often be found sufficient to build a masonry wall across the mouth of a gallery, and plaster it with mortar or mud in order to prevent leakage.

If the mines are fiery and there is a danger of an explosion, the dams (or stoppings as they are generally called) must be much more strongly built. They should be constructed with two curved walls, Fig. I, with five to six yards of well packed debris in between. This form, owing to the weight of the whole mass, gives stability, and the masonry is erected so as to best resist shock from either side.

But where there is a movement of the strata such as in the longwall method of working, masonry would crack and crush, and it is necessary to erect a dam which will yield with the pressure, and the materials of which will become more closely packed at the same time. Fig. II shows such a dam. It consists of three dry walls about 2½ feet thick, built of the rock taken down in the

mine for maintaining the height and width of the roadways, with about 4 ft. of dust and road scrapings, in a slightly damp state, well rammed in between the walls. This type of dam is very quickly erected and might often be adopted to divert a ventilating current during the preliminary measures undertaken in the case of an underground fire. The materials are at hand in the mine and speed may be of the greatest importance.

Another one which is quickly put up consists of four props set (Fig. III), so that A and B are about 2 ft. from C and D. Horizontal planks are then nailed roughly from bottom to top of C and D, these forming the inside of the dam. More planks are now strongly spiked on to A and B, and the space between the props rammed with earth or clay, the interstices between two consecutive planks being filled with hay.

Sometimes wooden blocks and mortar are used to construct a dam. The materials are more quickly put together than in the case of masonry, and the dam so built is better able to withstand pressure without leakage.

Dams made of timber should not of course be erected in any place where there would be the faintest possibility of fire coming into contact with them.

Where it is necessary to build a dam in close proximity to a fire, some refractory material such as sand must be used as a lining to the masonry. This resists the action of the heat and at the same time prevents access of air.

In Fig. IV, smoke appeared issuing through two cracks A, A′, in one of the pack walls forming a side of the roadway shown. The cracks were first filled with dirt, which reduced the quantity of smoke coming out, and permitted a brick wall B, with a lining of sand C, to be put in. This structure shut off the fire and gave sufficient

time to enable the roadway to be filled up with sand, well rammed in, and permanently sealed off by two masonry walls, one at each end.

The dam shown in Fig. I, but with sand filling, is a good type of barrier to prevent access of air to fire areas.

Under certain circumstances the necessity of sealing off large bodies of water of great head may arise, *e.g.*, in a mine fire where it is desired as a last resort to isolate one portion of a mine, or to flood another, or where two collieries are worked conjointly and one has to be abandoned. Such a need is also very probable under the conditions which may be supposed to exist at some future time in the Bengal coal-fields when the coal near the outcrops will have been exhausted, and where owing to the great thickness of the seams, the subsidence of the surface will cause large accumulations of water necessitating very heavy pumping from shafts to the dip. To avoid the expenditure entailed thereby barriers of coal will have to be left and in some cases dams will have to be erected.

The following preliminary considerations are necessary in the case of dams to seal off water :—

1. The permeability of the strata.
2. The choice of materials for construction.

The first enables the site of the dam to be fixed. This should be in impervious strata with no fissures or cracks which would permit water to leak through.

The site is of primary importance. Examples are on record of much labour and money having been expended in building elaborate dams finally to find the water pouring through the strata under a moderate pressure, far below that which they were designed for.

The second will depend on whether a slight movement

of the strata is to be feared at some future date after erection. If so, then timber is the best material to use, but if not, the dam may be constructed of masonry or concrete.

A dam constructed of timber possesses greater flexibility and would admit of slight changes in its original form without losing any of its strength or leaking, when movements occurred in the surrounding strata. Whereas under the same conditions masonry or concrete would crack, causing leakage and probable failure. On the other hand timber dams deteriorate with age much more quickly and are more expensive to erect owing to the extreme accuracy required.

It would next be necessary to decide :—

3. The form of the dam.
4. The thickness necessary to resist water pressure.

There are three forms which are generally used in practice, *viz.* : (*a*) The parallel dam consisting of a solid block of masonry built across the gallery, and depending for support on adhesion to the sides ; (*b*) The cylindrical ; (*c*) The spherical.

Masonry or concrete may be used for either of the three forms, but dams built of timber are usually made spherical.

To determine the thickness of a parallel dam, it may be considered as being under the same action as the material of a boiler-plate when a punch makes a rivet-hole in it. The area of the curved surface of the hole multiplied by the breaking shearing stress of the material per sq. in. represents the force with which the punch must be pressed down on the plate. The combined areas of the four faces of the dam in contact with the roof, sides, and floor,

represent the area of the surface of the rivet-hole, and the total pressure on the dam represents the force on the punch. In vol. xxvi, page 180, of the Transactions of the Fed. Inst. of Mining Engineers, it is stated that as the result of experience gained by the erection of several dams, it has been found sufficient to calculate the thickness by using a shearing stress of $15\frac{1}{2}$ pounds per sq. in. In an example given, a masonry dam, to resist a head of 360 feet, had a maximum sectional area of 60 sq. ft. and a thickness of 19 ft.

In the cases of cylindrical and spherical dams the thicknesses are usually determined by formulæ based on two assumptions: (*x*) That the average stress only has been considered, and (*y*) that the stress is supposed to increase uniformly from the inside of the abutments outwards.

The thickness of a cylindrical dam based on the first assumption may be found from the rule: "The total pressure on each abutment for each foot in height is equal to the fluid pressure in pounds per sq. ft. multiplied by the radius of the dam in feet." (See vol. III., page 52, "Transactions, Mining and Geological Institute of India".)

On the second assumption Prof. W. Steadman Aldis* gives the following formulæ:—

Cylindrical dam—

$$K = r\left(1 - \sqrt{1 - 20\,P/T}\right) \quad \ldots\ldots\ldots\ldots\text{(i)}.$$

Spherical dam—

$$K = r\left(1 - \sqrt[3]{1 - 15\,P/T}\right) \quad \ldots\ldots\ldots\ldots\text{(ii)}.$$

where K is the minimum thickness, r the greatest radius, P the pressure of water per unit area, and T the ultimate

* Transactions, N. E. Inst., 1883, vol. xxxii, page 201.

crushing strength of the materials used in construction. A factor of safety of 10 has been allowed for in the formulæ.

It will be noticed that the last two formulæ fail when $20\,P/T$ and $15\,P/T$ are respectively greater than unity. If the material used in constructing a cylindrical dam is for example brickwork, with an ultimate crushing strength of 1,200 lbs. per sq. in., then the limit is reached when $P = 60$ lbs. per sq. in., which represents a head of about 138 ft. But if timber, with a crushing strength of 6,000 lbs. per sq. in. is used, the formula becomes applicable for heads up to 690 ft.

PREPARATION OF THE SITE.

This must be performed with great care and entirely without the use of explosives. The rock must be cut with picks, or hammers and chisels, until finally it has an absolutely solid ring over all its faces when struck. At the same time the roof and sides must be properly shaped in order to receive the materials.

In the case of spherical dams the centre of the sphere should be fixed by hammering a spike into a prop securely tightened. This forms the apex of the pyramid formed by the four sides of the gallery, which can then be accurately cut to radii from the spike (see fig. VIII). In the event of the faces being rough when the dressing has been completed, they should be cemented.

In preparing the abutments for a cylindrical dam a square prop may be put up so that one of the diagonals is in the centre line of the roadway, the front edge representing the axis. By using a straight edge the strata can be trimmed to shape.

In the case of a parallel dam the sides should possess plenty of recesses.

It is this work that occupies most of the time taken, and it cannot be done with too much care.

CONSTRUCTION.

The most common type of dam is that made of timber such as oak, or pitch pine, which must be well seasoned and quite sound. The pieces are usually from 4 to 8 ft. in length, squared and tapered, and trimmed on the surface, where also the carpenters prepare the timber to receive the manhole pipe, which is fixed in the middle of the dam, to enable the workmen to pass inside. Sometimes also an additional overflow pipe is fitted near the bottom and a small pipe near the top to carry off the air which may be imprisoned. The latter pipe will subsequently serve for attaching a pressure gauge. (See fig. IX). Each block (voussoir) is numbered and finally put into the dam in a dry state. During the construction, the blocks fitting against the sides, roof, and floor, are painted with red lead and laid in position. They are then withdrawn, and any inequalities are planed off. In this manner perfect contact is obtained. In some cases recorded the voussoirs have been finally laid on a bed of moss stuck to the rock by means of tar. In others well-tarred brattice cloth was laid between each bed or course, and also between the voussoirs. When the whole of them have been laid in position, the process of driving wedges into the timber on the side which will be in contact with the water, is commenced. Wedges of soft wood like fir, about 12 in. sq., and 2 in. thick, and quite dry, are first of all driven in. Afterwards dry oak wedges 4 in. to 6 in. long are driven in, holes being prepared by first driving in a steel wedge and then extracting the latter. This is continued until it is impossible to get more timber wedges

in. Then to make it quite watertight, some hundreds of steel wedges are hammered in around the edges. The workmen now retire through the manhole. This, as well as the drain pipe, is then closed by a plug of wood on the inside or a blind flange on the outside, and the water allowed to accumulate. After a short time the timber swells under the action of the water and the dam will be quite tight.

In Mr. G. G. Andrè's "Practical treatise on Coal-mining," an example of a spherical dam which was built to resist a head of 707 ft. is given. The external radius is 16 ft. 6 in., length of the voussoirs 5 ft. 6 in., convex area 112 sq. ft., and concave area 49½ sq. ft.

Figs. V, VI, VII illustrate a typical example of a cylindrical dam made of brickwork. The bricks are laid in separate rings and the joints crossed both horizontally and vertically, the thickness of each ring being the length of a brick. Between two consecutive rings there is a space varying from 1 in. to 2 in. wide which is filled with cement. Thus between the rings there are vertical sheets of cement reaching from the floor to the roof. Again, where the brickwork fits against the abutments, a layer of cement must be poured in to make a good joint and to fill up any cracks or unevennesses. In this manner an impervious surface of cement is offered to the water at all points. The bricks themselves, with fairly high pressures, would sweat the water through, causing leakage, and such would happen if the work were bonded. The greatest difficulty in the construction is to make a good joint between the brickwork and the roof, because the work always subsides a little on setting. This may be got over by not building too quickly, and by having the sides of the dam nearest the water highest, so that after the subsidence has occurred cement

can be well rammed in by means of a flat timber wedge about $\frac{1}{2}$ in. thick at the end. In the figures, six rings of bricks are shewn with an overflow pipe varying from 4 in. to 12 in. in diameter at the bottom, and a manhole 14″ × 18″ in the middle of the dam. An arch with an invert, the whole surrounded by a layer of cement concrete, well rammed, is shown built on each side of the dam. The arches may be put in afterwards and form a protection to the dam in case of any movement of the strata. A pressure gauge is usually fitted to one of the blind flanges closing up the pipes.

In Vol. iii, page 132, "Trans. Fed. Inst. Mining Engineers," an example is given of such a dam, built of bricks set in Portland cement, and consisting of six rings, the total thickness being $5\frac{1}{2}$ feet. It is situated in a coal seam and withstands a head of 250 ft. without leaking.

Figs. X, XI show a cylindrical dam built of local sandstone and cement mortar consisting of one part cement, and two parts sand, and situated in slate in a drift 6 ft. wide, and $7\frac{1}{2}$ ft. high. The abutments were cut along radial planes leaving the faces rough. The two or three front courses only were cut to fit the arch. The dam was situated at a depth of 800 ft., and was designed to withstand a pressure of 350 lbs. per sq. inch. When the pipes were closed, and the water allowed to rise, it commenced to leak, and the leakage increased as the pressure rose. So the water was let off, and after lengthening the pipes, a brickwall 22 in thick was built at a distance of 28 in. from the inside of the dam. The intervening space was filled with concrete made of four parts limestone, broken to egg-size, with three parts cement. Finally, before closing it, three loads of horse manure were placed against the brickwork and kept there by a plank partition. In a week the

gauge registered a pressure of 277 lbs. per sq. in., and the leakage was $2\frac{1}{2}$ gallons per minute.

Figs. XII, XIII, XIV illustrate an example of a concrete dam, built in a gallery in the Idria mines, Austria, where an inrush of water was threatened through a rock fissure communicating with the bed of a river. Previous efforts to keep back the water with ordinary transverse dams had failed.

The gallery was first widened all round and the exposed rock surface swept clean of dust by steel brushes. The work of lining the gallery was commenced some distance in front of the old dam, so as to leave finally a space of about 6 ft. in order to leave room for a washout of the drain pipe in the event of its getting choked up.

The concrete was made of one part slow-setting Portland cement, two-and-a-half parts washed river sand, and three-and-a-half parts of limestone chippings up to 2 in. diameter. It was laid in sections 6 ft. 8 in. long, the bottom and sides being rammed, whilst the roof section, of plastic concrete, was pressed into position by suitably shaped tools, and supported by a timber lining. The end surface of each section was recessed (fig. XIII) to make a better joint, and both this surface and the face of the rock were well swept, damped, and coated with fine sand cement mortar, before commencing the next section. A period of eight hours was allowed to pass after the completion of each section before proceeding with the next. In this manner a length of 46 yards of concrete lining was put in.

The portion next to the old dam was next erected, the gallery having already been tapered off as shown in fig. XII.

When the concrete had set the valve on the drain pipe was closed. After an interval of eight hours the gauge registered a pressure of 174 lbs. per sq. in., and an inrush of

water appeared at a point in the lining about 30 yards from the barrier. On opening the valve the pipe was found to be choked, so the rest of the lining was put in, the total length being 90 yards. The leakage afterwards subsided to a slight extent. The dam completely fulfilled its purpose of shutting off the water.

Fig. XV is the plan of a dam designed to resist a pressure of 285 lbs. per sq. in. It was placed in a drift rising 30°, sectional area $11\frac{1}{2}$ ft. $\times 6\frac{1}{2}$ ft., in a bed of sandstone 20 yards thick. It is built in the form of three trunks of pyramids with spherical bases, each about 19 ft. long, the contractions being arranged so as to form a solid plug of masonry 57 ft. in length. The sides are widened at the base of each pyramid to 23 ft., and the top and bottom similarly widened to 13 ft. The sides were dressed to the proper form, by means of the pick, as carefully as possible, and covered with a layer of Portland cement $\frac{3}{4}$ in. thick. The dam is built of hard, well burnt common bricks, and mortar made of equal parts of hydraulic lime and sifted ashes, and the bricks were soaked in water before being laid. A drainage pipe, provided with a wheel valve and furnished with collars, was built into the centre of the masonry, and a wrought-iron tube, $\frac{3}{4}$ in. diameter, was built into the top to provide for the escape of air and subsequently to serve for attaching a pressure gauge. Two months after its completion the gauge registered a pressure of 18 atmospheres.

Finally, fig. XVI is a sketch of a dam erected in a shaft. It consists of a masonry arch built in a specially prepared position, the strata having been dressed solely by the use of the pick. The top of the arch is covered by a layer of well-rammed concrete on which rests a substantial thickness of well-puddled clay. The clay is protected by a

layer of masonry, the top course consisting of thick stone flags. A pipe passes through the dam to carry off the water during erection. A somewhat similar structure has been erected in the abandoned Dinas upper pit, Rhondda Valley, in order to prevent the passage of water from the house coal seams and Pennant rocks to the steam coal area below, which is being approached from an adjoining colliery.

ABSTRACTS.

The Conservation of Natural Resources.

To mining men and economists in all parts of the world the Convention of Governors, their advisers, and leading engineers of the United States, called by President Roosevelt at Washington during May, 1908, must be of the greatest interest. The object of the Conference was to consider the great question of the depletion of natural resources by the modern rapidly increasing rate of exploitation. In the United States, the deforestation of large areas has become a serious question ; and those interested in the future of the country are beginning also to be alarmed at the great destruction and waste of the natural water-supplies as well as of the minerals, especially of coal, oil, gas, and iron. It is evident that responsible statesmen in America are beginning to consider the desirability of acquiring State control over certain natural resources now managed by trusts and companies, who have less regard than the Government for the future, and only such regard for the consumer as competition enforces.

An interesting address, read before this Conference by Andrew Carnegie, is reprinted in the *Engineering and Mining Journal of New York*, Vol. 85, p. 1051, May 23rd, 1908. Mr. Carnegie points out that, during the 75 years, from 1820 to 1895, nearly 4,000 million tons of coal were mined in the United States, and he estimates that the methods employed were so wasteful that something like 6,000 million tons were at the same time either destroyed or allowed to remain in the ground for ever inaccessible. During the ten years, from 1896 to 1906, about the same quantity of coal was produced, and at the same time something like 3,000 million tons were destroyed during the process of mining. The production of coal in the United States during 1907 was about 450 million tons, and at the present rate of increase the production in 1927 will be 1,800 million tons, and in 1937 over 3,500 million tons. Mr. Carnegie thus estimates that, at the present rate of consumption, making due allowance for economies that can be foreseen, the principal part of the known coal supplies of America will be exhausted within the next 200 years. To each generation the

ultimate disappearance of coal is of less concern than the current prices, which are advancing with the cost and increasing difficulties of turning the less productive seams to account.

With regard to the American resources in iron-ore, Mr. Carnegie estimates a stock of about 1,500 million tons in the Lake Superior District, and of 2,500 million tons in the southern iron-fields, with 5,000 to 7,000 million tons in other parts of the United States. He estimates the total, therefore, of iron-ore in the United States to be about 10,000 million tons. The aggregate production to date of iron-ore in the States amounts to 750 million tons, *i.e.*, about 1-13th of the total visible supply. At the recent rate of increase (doubling each decade), the production in 1938 will be over 4,000 million tons, that is to say, in that year, which many people now living may well expect to see, the amount of ore produced will be equal to the entire production of the United States up to the end of 1906. By the year 1938, Mr. Carnegie estimates that half the iron-ore supplies of the United States will have been exhausted, and all the ore now considered to be workable will be used up long before the end of the present century.

He discusses the rapid exploitation and waste of copper, lead, zinc, and gold, although, with regard to these metals, the figures are confessedly less precise, and possibly less alarming than in the case of iron.

In view of the sobering facts presented, the thoughtful man is forced to realise—(1) that the production and consumption of minerals are increasing much more rapidly than the population, and (2) that the methods now in use are so faulty and extravagant that the average waste is very great, in coal, almost as great as the amount consumed. It is serious to learn that what was regarded at one time as an inexhaustible supply of iron-ore will hardly outlast the generation now appearing, leaving only the leaner ores for the later years of the present century. Besides pleading for economy, such as is now possible but generally neglected because of the great haste to secure immediate profits, Mr. Carnegie urges the endowment of research into industrial processes for the sake of reducing the waste of natural resources. At the same time, he indicates certain directions in which economies may be effected; for instance, with regard to iron, he advocates a lessening of the demand for the metal by the development, where possible, of water-carriage instead of railways; for transport by water not only

means the use of less iron in the materials employed but also of less coal for the smaller amount of power required. In the construction of buildings and bridges, the increased use of concrete, simple and reinforced, will do much towards reducing the consumption of steel; and next he points out the economic advantages of what he regards as an awakening of the public conscience and of the sense of national righteousness whereby civilised nations must be led to adopt those moral standards which already regulate individual conduct; international understanding will do much towards reducing the consumption of steel for the construction of battleships, ordnance, projectiles, and small arms. The gradual improvement of alloys of iron with silicon and other elements give promise of the production of a superior metal and the utilization of siliceous ores hitherto unworkable.

As regards economies in coal consumption, he points out that the modern furnace and fire-box waste 90 per cent. or more of the potential energy of the fuel employed in power production. Internal combustion engines and gas-producers, by doubling or trebling the power per unit of coal, will effect certain economies in the use of a better class of coal, and will also permit of the utilization of the poorer qualities. Coke-making should, if necessary, be regulated by the State, in order that all coking processes should utilise at least the furnace gases for power and heat, if not for the recovery of the minor by-products. The most promising check on coal consumption is the substitution of other power. Solar heat and water power (which is a product of solar heat) should be more thoroughly used for the production of power by the medium of electricity.

T. H. Holland.

Test for Coking Coals.*

While studying the physical properties of coal, Mr. M. A. Pishel observed that the best coking coals adhered more strongly to the mortar while being pulverized than the non-coking coals, the latter adhering very slightly or not at all. As this observation gave promise of affording a simple and inexpensive method of distinguishing coking from non-coking coals, the writer examined 150 samples of American coal, comparing this peculiar feature with their coking properties. His plan is

* "A Practical Test for Coking Coals." By Max A. Pishel. Economic Geology, Vol. III, 265, June-July, 1908.

described as follows:—Pulverize in an agate mortar a small quantity of the coal to be tested until it will pass through a 100-mesh sieve. Pour out the pulverized coal and observe the condition of the mortar and pestle. With some coals the mortar and pestle will be deeply covered with a coating of coal dust which adheres so strongly to the agate surface that it is removed with difficulty; with other coals there will be only a thin film of coal dust adhering to the mortar and pestle while with still others both mortar and pestle will be nearly as clean after the coal is pulverized as they were before the operation began

In addition to the adhesion of the fine particles to the mortar, some coals show a tendency to pack together or cohere. Although this phenomenon appears to be limited to coking coal, it is thought to be more dependent on the moisture content than on its coking quality but sufficient work has not been done to determine this point. The author describes the scale of adhesion as follows:—(1) *None;* (2) *poor;* (3) *medium;* (4) *good;* and (5) *excellent.* Coking coals range between *medium* and *excellent*, while non-coking coals range from *medium* to *none.* Those marked *medium* are doubtful in their character, and may or may not possess coking qualities. If they do produce coke, it is generally of a poor quality, worthless for commercial purposes. It is possible that, for application to Indian coals, the scale of adhesion will require modification, as a higher ash percentage and a high percentage of moisture might affect the adhesive characters of the coal. The author does not regard his system as perfect or universally reliable, but merely suggests this rough and rapid test for further examination, and with this object in view the subject is brought to the notice of the Institute.

T. H. Holland.

Orthoclase and Microcline.*

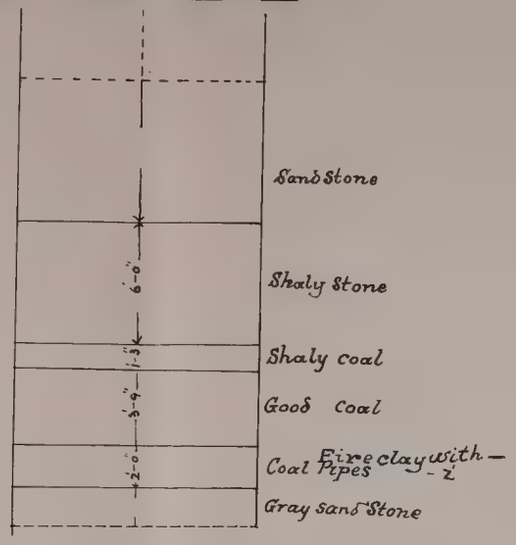
The investigation recently conducted by M. Ph. Barbier into the composition of the potash felspars proves to be of great interest to mineralogists. M. Barbier has found, by examination of a large number of specimens, that *ordinary orthoclase* contains small quantities of lithium or rubidium and sometimes both of these elements with the

* Recherches sur la composition clinique des felspaths potassiques. By Ph. Barbier, *Bull. de la Soc. Fr. de Min.*, XXXI, 152, 1908.

potassium, while *microcline* is devoid of both lithium and rubidium. Mineralogists have been in the habit of regarding microcline as a mere physical variety of orthoclase, marked by a peculiar form of repeated twinning and having an angle of about 89° 30′ between the faces (001) and (010) instead of the true right angle that should exist in monoclinic crystals. M. Barbier now shows that there is a chemical difference at the root of these differences in crystallographic characters, and the two minerals should thus be regarded as distinct species.

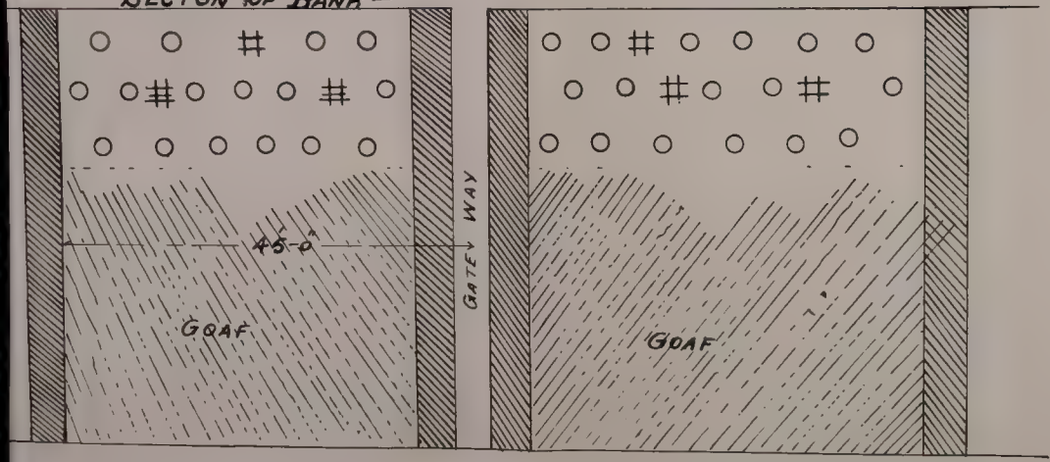
T. H. Holland.

SECTION OF No3 PIT



METHOD OF TIMBERING LONGWALL FACE

SECTON OF BANK

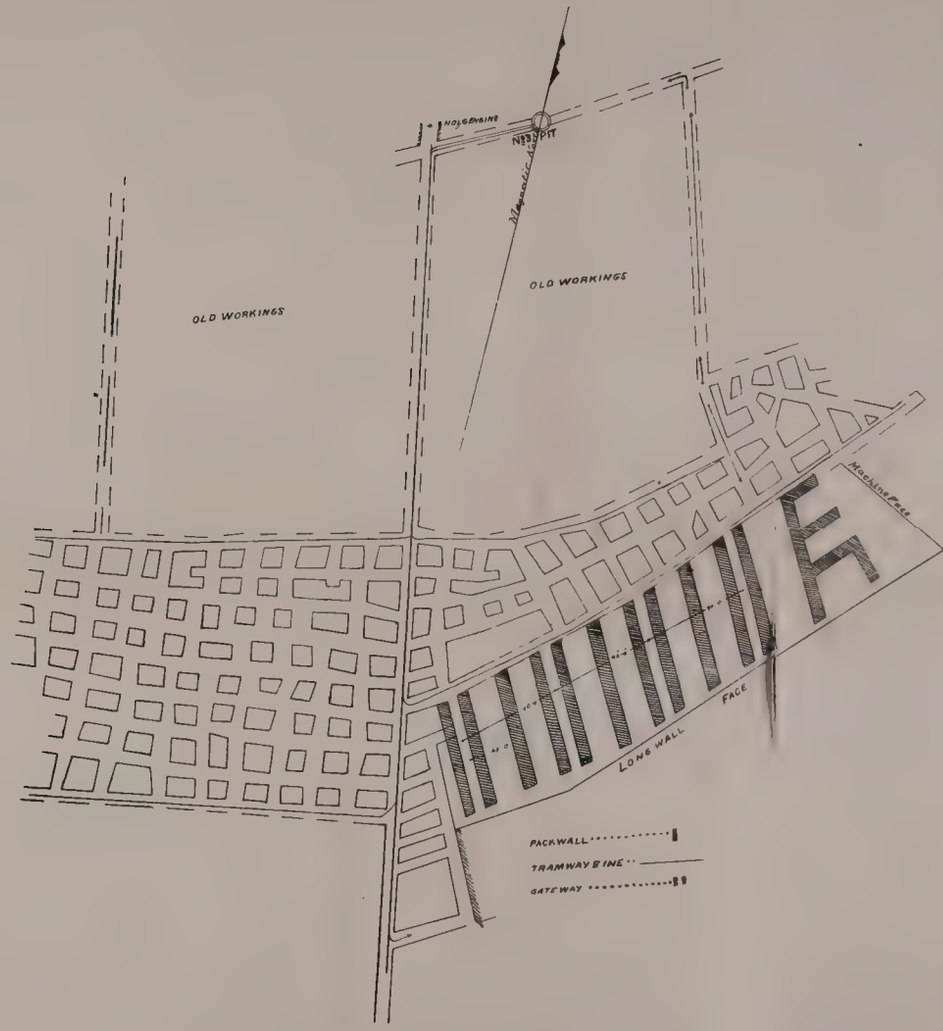


MINING AND GEOLOGICAL INSTITUTE OF INDIA.

WILLIS HOWARTH.

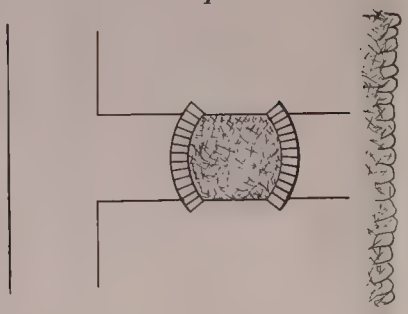
Longwall Method of Working Coal at the Sitarampore Coal Company's Collieries, Nursamooda.

Transactions, Vol. III, Pt. 1.



W. T. GRIFFITHS,
Mine Dams.

I



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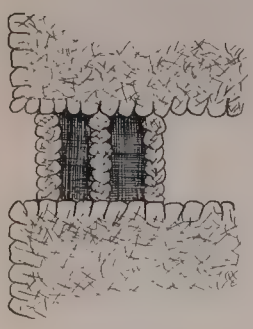

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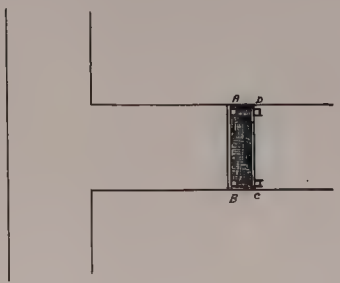

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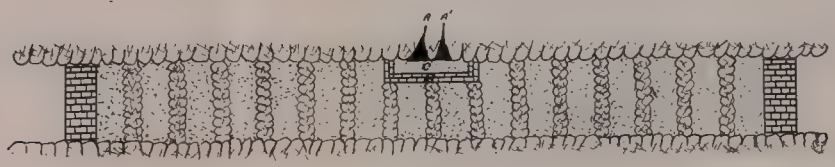
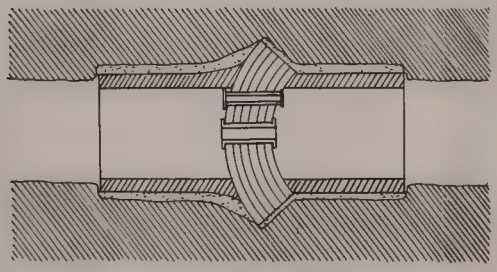
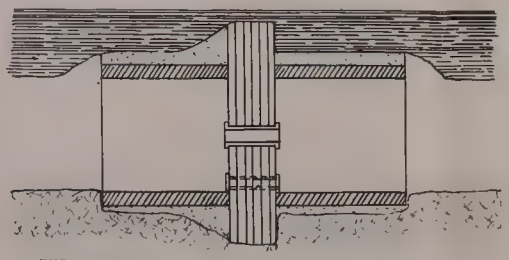


V $\frac{1}{50}$ CYLINDRICAL DAM OF MASONRY

PLAN



VI SECTIONAL ELEVATION



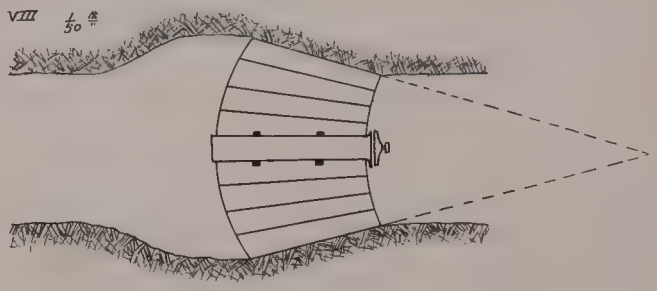
VII END ELEVATION

MANHOLE. PIPE

SPHERICAL DAM OF WOOD

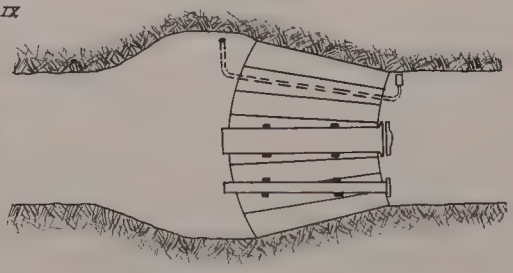
PLAN

VIII $\frac{1}{50}$



ELEVATION

IX



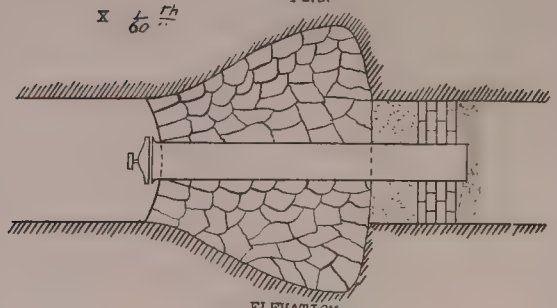
W. T. GRIFFITHS,
Mine Dams.

Transactions, Vol. III. Pl. III.

CYLINDRICAL DAM

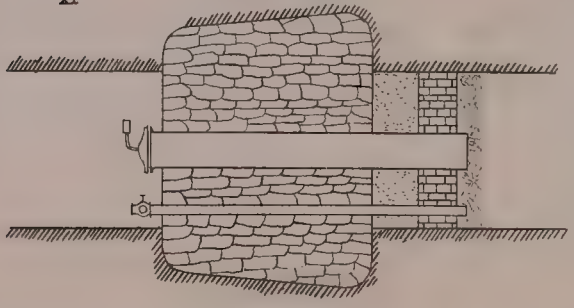
PLAN

X 1/60 th



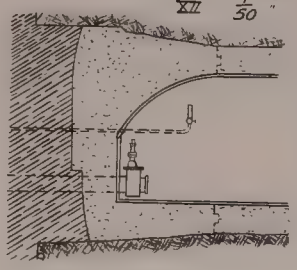
XI

ELEVATION

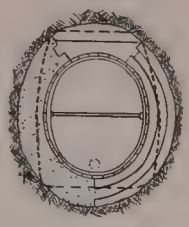


CONCRETE DAM

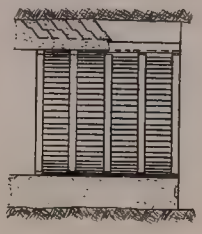
XII 1/30 th



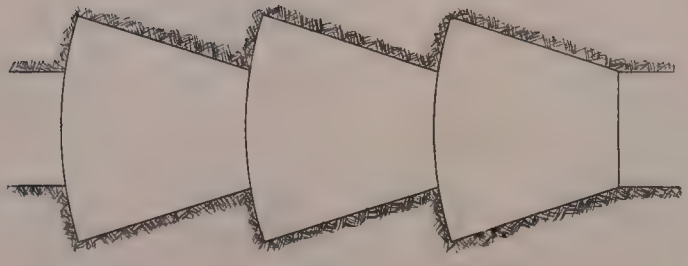
XIII



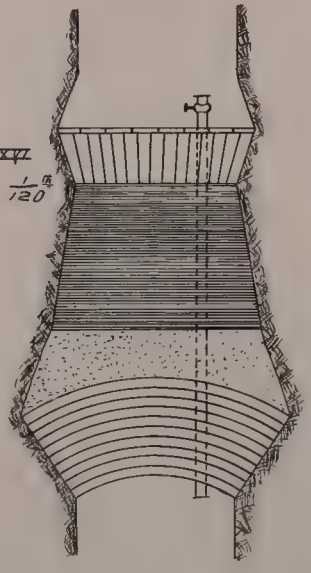
XIV



XV 1/120 th



XVI 1/120 th



Meeting at Dishargarh.

Monday, 23rd November, 1908.

By the kind invitation of the Equitable Coal Company, Ld., a meeting of the Institute took place on Monday, the 23rd November, 1908, at Dishargarh. The collieries were inspected under the guidance of the President of the Institute, Mr. Miller, and the members were entertained by the Company at tiffin and tea in the local club.

Arrangements were made for the conveyance of members by special trains starting on Monday morning, the 23rd November, from Jherria at 6-30 A.M., from Katrasgarh at 6-15 A.M., and from Raniganj at 7-30 A.M., and by special carriages attached to the train leaving Calcutta at 22.06 on Sunday evening, the 22nd November. It was also arranged that the special trains should return to Jherria, Katrasgarh and Raniganj on Monday evening after the meeting, and the special carriages for the return of Calcutta members should be attached to the No. 18 Down arriving at Calcutta at 5-0 A.M. on Tuesday morning.

The special carriages were collected at Asansol, starting thence about 9-30 and arriving in the colliery sidings at Dishargarh at 10-30. The train left again for Asansol at 4-30. Many of the members arrived in motors or driving and some of the trains were utilised to a very small extent. Over a hundred members and guests of the company

assembled, however, and were met by the President. Four parties were made up as follows:—

No. 1 *Party.*—W. Miller, W. M. Martin, W. Dring, J. Manson, J. J. Turnbull, G. C. Leach, A. Whyte, O. Strachey, G. Peddie, S. Heslop, W. Foster, R. Mitchell, R. Barrowman, W. McFarlane, G. F. Scott, H. G. Graves, Dr. Macconell, G. C. Lathbury, E. Sommerfeldt, R. Highet.

No. 2 *Party.*—Geo. Miller, C. Nairne, J. G. Maughan, L. A. Jacob, W. V. Hannaford, C. T. Ambler, H. C. Veasy, E. H. Roberton, R. J. Browne, F. L. Cork (Senior), H. Walker, F. J. Agabeg, Geo. Dixon, Theo. Fleischer, A. G. Christian, E. M. Patterson, P. W. G. Scott, V. E. D. Jarrad, A. Mitchell, Thos. Adamson, Dr. W. O'Connor, E. Flewker, H. Webber, Geo. Shearer.

No. 3 *Party.*—T. Morrison, F. L. Cork (Junior), W. Howarth, H. W. Loughran, E. S. Bennertz, F. T. Marley, F. B. Maltly, R. L. Frizoni, C. L. Watson, G. H. A. Armstrong, A. H. M. Paton, E. D. Oneart, G. N. A. Pitt, A. V. Sam, C. Lea, Thos. Chrystle, T. C. Piggford, W. J. Rees, R. W. Malcolm, H. G. Ambler, W. Hullock, G. Temple, A. Gillespie, Theo. Ashley.

No. 4 *Party.*—D. Blair, A. Finlayson, A. Pennifather, H. L. Wilkinson, A. T. Creet, P. H. Ashcroft, E. N. Forbes, D. A. Whyte, C. H. McCale, W. E. Lawrie, J. W. Neirses, R. Heron, C. A. Forbes, W. Augier, E. G. Seth Sam, J. A. Oliver, A. Russell, P. Brimlow, G. S. Martin, T. B. Foster, G. K. Mitchell, R. Aitken, A. G. Bennertz, N. N. Mukherji, A. H. Higby.

The first and third parties went down No. 6 Pit, while the second and fourth went down No. 3. Pit, but all managed to see the surface workings at some of the other pits. Details of the plant are given below.

DESCRIPTION OF MACHINERY, DISHARGARH COLLIERY, EQUITABLE COAL COMPANY, LIMITED.

No. 1 Pit.

Winding Engines.

The Winding Engines are by Messrs. Gibb & Hogg, Engineers, Airdrie N.B. They consist of a Coupled Horizontal Engine with Steam Cylinders, 24 inches diameter by 48 inch stroke, and the drum is 10 feet diameter.

The depth of wind is 503 feet and the Engines are designed to wind from this depth with 40 lbs. effective steam pressure.

Steam Boilers.

The steam is supplied by five Lancashire Boilers to the Winding and Haulage Engines and Main Pumps and are of the following dimensions:—

No. 1 Boiler 7′ × 27′ made by J. Musgrave.
No. 2 ,, 7′ × 27′ ,, Clarke Chapman & Co.
No. 3 ,, 7′ × 27′ ,, ,, ,, ,,
No. 4 ,, 7′-6″ × 30′ ,, Wm. Arnott & Co.
No. 5 ,, 7′-6″ × 30′ ,, ,, ,, ,,

All have a working pressure of 100 lbs. per sq. inch.

Feed Pump.

The boilers are fed with a Donkey Pump having a 10″ diameter Steam Cylinder and a 7″ Ram by 9″ stroke; made by John Cameron, Manchester.

Haulage.

There is one main Rope Haulage, winding from the dip on a gradient of 1 in 5, and the length of this haulage is 2,300 feet.

assembled, however, and were met by the President. Four parties were made up as follows:—

No. 1 *Party.*—W. Miller, W. M. Martin, W. Dring, J. Manson, J. J. Turnbull, G. C. Leach, A. Whyte, O. Strachey, G. Peddie, S. Heslop, W. Foster, R. Mitchell, R. Barrowman, W. McFarlane, G. F. Scott, H. G. Graves, Dr. Macconell, G. C. Lathbury, E. Sommerfeldt, R. Highet.

No. 2 *Party.*—Geo. Miller, C. Nairne, J. G. Maughan, L. A. Jacob, W. V. Hannaford, C. T. Ambler, H. C. Veasy, E. H. Roberton, R. J. Browne, F. L. Cork (Senior), H. Walker, F. J. Agabeg, Geo. Dixon, Theo. Fleischer, A. G. Christian, E. M. Patterson, P. W. G. Scott, V. E. D. Jarrad, A. Mitchell, Thos. Adamson, Dr. W. O'Connor, E. Flewker, H. Webber, Geo. Shearer.

No. 3 *Party.*—T. Morrison, F. L. Cork (Junior), W. Howarth, H. W. Loughran, E. S. Bennertz, F. T. Marley, F. B. Maltly, R. L. Frizoni, C. L. Watson, G. H. A. Armstrong, A. H. M. Paton, E. D. Oneart, G. N. A. Pitt, A. V. Sam, C. Lea, Thos. Chrystle, T. C. Piggford, W. J. Rees, R. W. Malcolm, H. G. Ambler, W. Hullock, G. Temple, A. Gillespie, Theo. Ashley.

No. 4 *Party.*—D. Blair, A. Finlayson, A. Pennifather, H. L. Wilkinson, A. T. Creet, P. H. Ashcroft, E. N. Forbes, D. A. Whyte, C. H. McCale, W. E. Lawrie, J. W. Neirses, R. Heron, C. A. Forbes, W. Augier, E. G. Seth Sam, J. A. Oliver, A. Russell, P. Brimlow, G. S. Martin, T. B. Foster, G. K. Mitchell, R. Aitken, A. G. Bennertz, N. N. Mukherji, A. H. Higby.

The first and third parties went down No. 6 Pit, while the second and fourth went down No. 3. Pit, but all managed to see the surface workings at some of the other pits. Details of the plant are given below.

DESCRIPTION OF MACHINERY, DISHARGARH COLLIERY, EQUITABLE COAL COMPANY, LIMITED.

No. 1 Pit.

Winding Engines.

The Winding Engines are by Messrs. Gibb & Hogg, Engineers, Airdrie N.B. They consist of a Coupled Horizontal Engine with Steam Cylinders, 24 inches diameter by 48 inch stroke, and the drum is 10 feet diameter.

The depth of wind is 503 feet and the Engines are designed to wind from this depth with 40 lbs. effective steam pressure.

Steam Boilers.

The steam is supplied by five Lancashire Boilers to the Winding and Haulage Engines and Main Pumps and are of the following dimensions:—

No. 1 Boiler 7′ × 27′ made by J. Musgrave.
No. 2 ,, 7′ × 27′ ,, Clarke Chapman & Co.
No. 3 ,, 7′ × 27′ ,, ,, ,, ,,
No. 4 ,, 7′-6″ × 30′ ,, Wm. Arnott & Co.
No. 5 ,, 7′-6″ × 30′ ,, ,, ,, ,,

All have a working pressure of 100 lbs. per sq. inch.

Feed Pump.

The boilers are fed with a Donkey Pump having a 10″ diameter Steam Cylinder and a 7″ Ram by 9″ stroke; made by John Cameron, Manchester.

Haulage.

There is one main Rope Haulage, winding from the dip on a gradient of 1 in 5, and the length of this haulage is 2,300 feet.

The Engine is by Messrs. A. Barclay & Co., Kilmarnock, and consists of a Coupled Horizontal Engine geared 4 to 1 with Steam Cylinders 16″ diameter × 38″ stroke; the diameter of the drum is 5 ft.

Main Pumps.

These are of the double Cameron pattern supplied by Messrs. Geo. Robson & Co., Glasgow N.B.

There are two pumps of similar pattern and dimensions, placed near the pit bottom and forcing direct to the surface.

The Steam Cylinders are 24″ diameter and Rams 8″ diameter by 12″ stroke, and each has a capacity of 12,000 gallons per hour running at 40 revolutions per minute.

No 3 Pit.

Winding Engines.

These are by Messrs. A. Barclay & Co., Engineers, Kilmarnock.

They consist of a direct acting Coupled Horizontal Engine with Steam Cylinders 20″ diameter by 44″ stroke and a drum 9′-0″ diameter. They wind from a depth of 480 ft. with single cages and are designed to raise the load with 40 lbs. effective steam pressure.

Boilers.

There are two Lancashire boilers each 7′ × 27′ and made by Messrs. Jas. Carmichael & Co. These supply steam for Winding and Haulage Engines.

The working steam pressure is 50 lbs. per square inch.

Feed Pump.

The feed pump is by John Cameron with a Steam Cylinder 7 inches diameter and a Ram 5″ × 6″ inch stroke.

Haulage.

The Haulage Engine is by Messrs. A. Barclay & Co., Kilmarnock.

The Engine is a Coupled Horizontal with Steam Cylinders 14″ diameter and 42″ stroke and geared 3 to 1 with a drum 6ft. diameter.

The length of the wind is 2,650 feet on a grade of 1 in 5.

No. 5 Pit.

Winding Engine.

The Winding Engine is by Messrs. A. Barclay & Co., Kilmarnock. The Engine is a direct Coupled Engine with Steam Cylinders 22″ diameter by 54″ stroke and a parallel drum 12 feet diameter. The depth of the present wind is 224 feet with single cages.

The above Engine was designed for a much greater depth to suit future requirements.

Boilers.

There are 4 Lancashire Boilers constantly under steam, supplying steam for the Winding and Haulage Engines and Air Compressor; they are:—

No. 1. Boiler 7′ × 30′ by Thos. Beeley, Manchester.
No. 2. ,, 7′6″ × 30′ ,, John Thompson, Wolverhampton.
No. 3. ,, 7′6″ × 30′ ,, William Wilson, Glasgow.
No. 4. ,, 7′6″ × 30′ ,, William Arnott, Coatbriage.

All have a working steam pressure of 100 lbs. per sq. inch.

Feed Pump.

The Feed Pump is by John Cameron, Manchester. The Steam Cylinder is 10″ diameter with a 9″ diameter Ram × 7″ stroke and of single Cameron pattern.

Haulage.

The Haulage Engine is by Messrs. A. Barclay & Co., Kilmarnock. The Engine is a Coupled Horizontal with Steam Cylinders 16″ diameter × 36″ stroke and geared 7 to 1, and the drum is 6 feet diameter. The length of wind is 3,500 feet on a grade of 1 in 5.

Air Compressors.

No. 1 Air Compressor is a Single Horizontal High Pressure Engine, with a steam Cylinder 32″ diameter by 5 feet stroke and the Air Cylinder of same dimensions.

No. 2 Compressor.

This is a Compound Steam Engine with Condenser. The diameters of the Steam Cylinders are 20″ and 32″ respectively by 4′9″ stroke. The Air Cylinders are 20″ diameter × 4′9″ stroke.

This plant is by the Sandy-Croft Foundry Company, England. The above Compressors supply the power for working all the underground pumps except the main pumps situated in the pit bottom.

No. 6 Pit.

Winding Engines.

The Winding Engine is by Messrs. A. Barclay & Co., Kilmarnock. The Engine is a Coupled Horizontal direct acting with Steam Cylinders 20″ diameter × 3′8″ stroke, and the diameter of the drum is 9 ft. parallel.

The depth of the wind is 400 ft. with single cages, and the Engines are designed to raise their load with 40 lbs. effective steam pressure.

Boilers.

There are four Lancashire boilers under steam supplying the power for the Winding Engine, two Haulage Engines, one Main Pump and the Electric Engine.

The boilers are of the following dimensions:—

No. 1 Boiler 7′ × 30′ by John Thompson.
No. 2 ,, 7′ × 30′ ,, Penman & Co.
No. 3 ,, 7′ × 27′ ,, Musgrave & Co.
No. 4 ,, 7′ × 27′ ,, ,, ,,
No. 5 ,, 7′ × 30″ ,, D. Adamson.

The working pressure of the range is 70 lbs. per sq. inch but four of the boilers in the range have a working pressure over that.

Feed Pumps.

The Feed Pump is by John Cameron & Co. and of their design. The Steam Cylinder is 8″ diameter and the Ram 6″ diameter with a stroke of 8.″

Haulage.

There are two Haulages in this Pit. No. 1 Haulage Engine is a Coupled Horizontal Geared Engine, with Steam Cylinders 20″ diameter × 3 feet stroke geared 2 to 1 with a drum 5 feet diameter.

The length of wind is 1,500 feet on a grade of 1 in 5.

These Engines are by Messrs. A. Barclay & Co., Kilmarnock. No. 2 Haulage Engine is a Single Horizontal Geared Engine with Steam Cylinders 16″ diameter and a stroke of 2′-6″ ; it is geared 3 to 1 to a drum 5 feet diameter.

The length of wind is 1,500 feet on a grade of 1 in 5.

This Engine is by Messrs. A. W. Smith & Co., Glasgow.

thanks of the members of the Mining and Geological Institute of India for all the kindness and hospitality they have shown to us to-day. Mr. Miller, the Superintendent of the Company, and his Managers, have spared no pains in making the visit a pleasant one. In this they have admirably succeeded, for I think you will all agree with me that we have spent a most enjoyable and instructive day. We have seen what is undoubtedly one of the best equipped and most up-to-date collieries in Bengal, and we have been greatly interested in all that we have seen, and perhaps more especially so with the coal-cutting machinery, which we have seen at work and working successfully. The matter of coal-cutting machinery is engaging the attention of many at the present time, in view of and in the hope of its minimising to some extent the ill-effects of the great labour scarcity and difficulty—a difficulty that has always been with us, and I fear that is likely to remain with us, it having lately become more acute than ever. The adoption of coal-cutting machinery has been but slow, but it is gradually gaining ground, for in addition to what we have seen to-day, it is not very long ago that we saw it in operation in the mines of the Bengal Coal Co. Other concerns are introducing it, I may say including my own Company, and I think we shall, before very long, see a further material extension of its use into Indian mining.

The Equitable Coal Co., as many of you may know, is one of the oldest in Bengal, it and four or five others being, I believe, the only concerns in existence some 30 years ago. The development of the industry from that time has been great and general, but more especially within the last decade, when it has expanded enormously, there being now well over 100 Joint Stock Companies in existence, representing an enormous capital invested. Throughout all this

time, and through all the fluctuations of the coal trade, in good times, and in bad times, the Equitable Coal Co., with most of the older concerns, have well held their own, and I venture to predict will continue to hold their own in the future as in the past, built up as they are on solid foundations, and more especially those possessing coal such as the Deshargarh, Joyramdanga or Seebpore quality, or of the like excellence to that we have seen to-day.

Mr. Miller, the President of our Institute, has been for very many years the Superintendent of the Equitable Coal Co., and it is doubtless largely owing to his untiring energy and great abilities that the Company has reached to its present high standard of efficiency, and its high dividend-earning capacity; and I now have much pleasure in coupling his name with the toast.

In reply the President said :—

Let me first express regret and apologise that some one of our Board of Directors or a representative of our Managing Agents is not present to-day to reply to the toast of success to the Equitable Coal Co., Ld., just proposed so ably and so eloquently by my friend Mr. Heslop, the worthy Vice-President of our Institute.

I can assure you my Directors look upon it as a very high honour to have the Members of the Mining and Geological Institute of India, including our guests, visiting and inspecting Dishergarh colliery to-day. Although we have been unable to show you anything very much beyond the ordinary in the way of a Colliery fitted up in a general way, still we may claim for Dishergarh Colliery that, as an Indian colliery goes, it is among the most up-to-date. It is a very poor colliery where one can not see and learn something new, and it is to be trusted, gentlemen, that you

have been pleased with what you have been shown on your round of inspection.

Mr. Heslop has in his remarks been pleased to notice the success which has attended the working of the Equitable Coal Coy.'s collieries for some considerable number of years back, and he has been inclined to attribute that success to the management and superintendence of your humble servant. My modesty prevents me accepting that too flattering remark by Mr. Heslop. It is impossible for me to claim the whole of the credit of the Company's successful position at the present moment.

All through my management of the Coy.'s business and its Collieries, I have been ably and ungrudgingly supported by my Board of Directors and by our Managing Agents, without whose support and advice the Company could not have attained its present position under any management. The able assistance in the building up of the Company received from the various Assistants who have served under me from time to time deserves also favourable mention.

Mr. Heslop has just told you of the wonderful coal-cutting machine he saw to-day. It is to be regretted we had not more to show you of importance in that line. We have only one of the "Little Hardy Pick" machines at work, and this only as experimental, and to be honest with you, it has only been at work to-day for your special benefit. It is no fault of the machine that it is not at work regularly. The fact is our trials with it have been a fair success, the present drawback being the want of sufficient power to work the machine continuously. Although we have an air-compressing plant consisting of two air-compressors of fair dimensions as you would notice, yet it takes all the power we can produce from

these compressors to keep our underground dip pumps working, the whole of these pumps being worked by this air power.

Mr. Heslop, though, in his description of our coal-cutting plant no doubt had in his mind other coal-cutting machines which we had working for some years at this colliery and which he previously saw at work. I refer to the Jeffrey coal-cutting machine. We have had three of these machines on the colliery for the last twelve years, but it was not possible to show the members of the Institute these machines at work to-day for the very good reason they are at the present moment in a disabled and worn-out condition. A short description of the work done by these machines and the results obtained may be interesting. As already pointed out, the machines were introduced on the colliery about the beginning of the year 1896 and set to work during that year. The Jeffrey coal-cutting machine, as most of you are aware, is a chain-cutting machine driven by electrical power. It is certainly better adapted for long-wall working as most coal-cutting machines are up to the present day, with probably one or two exceptions. However, it was thought, taking into consideration all the varieties of machine available at that time, that the Jeffery was the most likely one to fit itself to the conditions of coal-mining in India. One machine was first tried and gave satisfactory results that such two others were obtained and set to work.

We found the machines undercut the coal with great ease, undercutting one gallery on the average in a shift of 8 hours. The cuts were 3 feet wide and 5 feet deep and 4 to 5 cuts in each gallery. Unfortunately three-fourths of the time was occupied in shifting the machine from one gallery to another. This can be well understood when it is

known that each machine weighed over 30 cwts. and had to be hauled up a gradient of 1 in 5. We gained sometimes if we had two galleries on the same level to work and undercut. This was the great drawback to making the machines an absolute success, and the labour employed never took kindly to the hard work involved in shifting the machines about from gallery to gallery. They jibbed many a time, and only by hard persuasion and paying good rates were we enabled to keep the machines at work during the time we did. The machines having ultimately got worn and requiring extensive repairs it was resolved to discard them altogether as they were a continual worry to get sufficient labour to work them.

With regard to cost of working per ton by these machines a simple figure may only be given. The cost per ton of coal undercut and won from the galleries worked by the machines—taking all charges into account, such as, wages, supervision charges, stores (including explosives), depreciation at the rate of 10 % per annum on the cost of the plant, and allowing interest at 6 % per annum on total value of same—works out, taken over an average of two years' working, at Rs. 1-0-6 per ton of coal raised. This may be said to be practically the same cost as by hand-labour cutting. The points in favour of working by these machines are as follow :—

1. For a lesser working area of galleries a greater output of coal was obtained than by hand labour.
2. The machines when placed in position in the gallery for undercutting, did their work very satisfactorily and undercut the coal with great ease.

The drawbacks to the machines may be stated as follows:—

1. The machines were too heavy and in a seam lying at an angle of 1 in 5 as at Dishergarh 75 % to 80 % of the time was lost in shifting them from one gallery to another.
2. The labour did not take kindly to the work of shifting the machines about, as it was hard and laborious.
3. A difficulty was also found in getting a sufficient number of proper labour to do the blasting and clear and load the coal, and also dress the galleries for the next cut.
4. The machines could not shear the sides although the later type of Jeffery coal-cutters have been, I understand, designed to do so. A lighter machine also is now being made.

The machines have now been discarded as previously mentioned, as we did not consider it would be advantageous, taking everything into consideration with the experience obtained during the years they were working, to put out any further expense on the extensive repairs they required, or in incurring the cost of getting new machines of the newer and lighter type.

For main heading work, however, these machines would answer admirably. Now to pass on from coal-cutting machines I have thought it would interest the members of our Institute to-day to give a short retrospect of the Equitable Coal Co., Ld., and of their Dishergarh colliery which we have just inspected.

First let me say—

The company was incorporated in the year 1863.

Its collieries when incorporated were Chowkidanga and Dhusul.

Previously both collieries had been worked as private concerns.

Chowkidanga was among the first collieries opened and worked in the Raneegunge coal-field, having been established in the year 1836. From the geological records it is found that only three other collieries existed before that date, *viz.*, Raneegunge established in 1816, Damulia in 1824, and Chinakuri in 1834.

Dhusul colliery was established in the year 1853 and had thus been working for 10 years before the Equitable Coal Co. was incorporated.

It might be interesting to members of the Institute to describe how these collieries were equipped with machinery in the early days. I regret I can find no record of this until the years 1867-68.

Chowkidanga colliery in 1867-68 consisted of 8 pits and one quarry, fitted with steam-engines as follows:—

One of 7 H.P.
,, of 5 H.P.
,, of 24 H.P.
,, of 13 H.P.
,, of 14 H.P.

From this it will be noted that only 5 out of the 8 pits were fitted with winding engines, the other 3 probably having been worked out and stopped by the year 1867.

The output of the colliery for 1867 was 15,12,330 mds. or about 56,000 tons, no mean output for those early days. In that year, only one other colliery surpassed that output, *viz.*, Searsole colliery which raised 15,35,558 mds. or 56,870 tons.

Dhusul colliery on the other hand, although in 1867 it had 8 pits, only raised 2,11,431 mds. or 7,800 tons. Only three of its pits were apparently equipped with steam winding engines as follows:—

One of 12 H.P.
,, of 8 H.P.
,, of 40 H.P.

Both collieries were worked on the pillar and stall system.

About the year 1866 the company established another colliery at Haripore situated about 3 and 4 miles from Chowkidanga and Dhusul. Four pits were sunk, one only being fitted with a steam winding engine 17 H.P. and of the beam type. The others were equipped with gins only.

These three collieries remained the only working collieries of the company until early in the seventies. During the interval the company's Directors and officials apparently had turned their attention to the acquiring of other coal properties in other than the Toposi side of the coalfield, where their then-existing collieries were all situated. It had been found no doubt that the coal seams then being worked were of poor quality, and that it was advisable in the interests of the company to acquire properties containing better quality of coal. Three new properties, *viz*:—Jamuria, Luchipore and Neamuthpore were therefore acquired, the latter two being in the Sitarampore district, and Jamuria further west in the field about 6 miles from Chowkidanga. Collieries were immediately opened on the Luchipore and Neamuthpore properties, but Jamuria remained unopened until many years afterwards owing to want of railway accommodation.

Later on in the seventies, the company acquired their Dishergarh property, and the first sod of the colliery you have inspected to-day was cut in the year 1876. By hand-boring operations carried on previously, the afterwards famous "Dishergarh seam" was discovered in the property. Nos. 1, 2, 3, and 4 pits were immediately sunk to this seam at depths varying from 60 to 130 feet. No. 1 incline, which is still working, was an afterthought, and was made about the year 1879 or 1880. This incline has now reached a total length horizontally of about 5,000 feet.

The first 4 pits sunk have now been stopped, except Nos. 1 and 3 pits which have been sunk to the lower seam known in the district as the "Sanktoria seam."

Dishergarh colliery has now therefore been established for 32 years. During the first 13 years it had no railway connection and all the coal was carted to Barakar. It can well be imagined that by such means of transport the progress of the colliery was slow, the output in the year 1888—89 averaging only 2,000 to 2,500 tons per month or 25,000 to 30,000 tons for the year.

In connection with the question of railway accommodation to Dishergarh and other adjoining collieries, it may be interesting to give a short history. The East Indian Railway, had, I believe, been approached in the early eighties to put in a branch line from a point near Sitarampore, but in those days were not so enterprising in the way of accommodating collieries with branch lines and sidings as they are at the present day under the able management of Mr. Dring, the present Agent, and who I am pleased to see with us to-day as a welcome guest, and also Mr. Manson, Agent of the B.-N. Ry., another equally welcome guest. I have no doubt Mr. Dring will agree with

me when I say it was a foolish policy on the part of the East Indian Railway at the time. But did the coal companies concerned show an any more enlightened policy? Certainly not. It can be proved by statistics that it would have paid the Bengal and the Equitable Coal Companies, the two companies mostly interested, over and over again to put in the line for themselves. Carting charges cost each company something like Rs. 30,000 per year, and this went on for many years, besides preventing the collieries from being developed to their full capacity. So blind to their own interests were the two companies that they were very nearly saddled with an extension of Messrs. Apcar & Co.'s present Luchipore branch line, the proposal having been actually surveyed and placed before Messrs. Apcar & Co. for approval and sanction. Fortunately I think for both companies Messrs. Apcar & Co. could not see their way to carry out the proposed extension.

Now I think it was about the year 1883-84 when another project saw the light of day, and which would have been of immense advantage to the collieries in this district. The Bengal-Nagpur Railway project from Sitarampore to Nagpore had received the sanction of Government and work was actually started on it in 1884-85, and visible signs of the work done can be seen to this day.

But what did the coal companies do to help on this project, which was going to be of such immense advantage to them? The first thing they did, and I can speak with authority for the Equitable Coal Co., although it occurred before my day, was to put in preposterous claims for compensation for the coal underlying the alignment. The Equitable Coal Co.'s claim was something like a crore of rupees. The party who hatched the claim discovered I do not know how many seams of great thickness underlying

Dishergarh property, the greater number of which I have been quite unable yet to trace or find.

The result of this mistaken policy was to stop the Bengal-Nagpore Railway Co.'s project for some years, and was also in a great measure the means of the Government of India passing the Land Acquisition (Mines) Act of 1885. It also resulted in the Bengal-Nagpore Ry. Co.'s main line being diverted, and, instead of forming junction with the East Indian Railway at Sitarampore and passing through our collieries here it now joins that line at Asansol, and a special branch line had to be made to serve the collieries here from Damuda some 6 miles distant.

This branch line was completed and opened about the middle of the year 1889, and ever since the outputs of the collieries went up with leaps and bounds until in a very short period they reached a very high average for Indian collieries, proving at once the great advantages of adequate railway accommodation.

Such then, gentlemen, is a brief history of the colliery you have inspected to-day, and I need hardly tell you it has been a very valuable asset, and will continue to be a very valuable asset to the Equitable Coal Co. for a great many years to come.

Notes on some of the Exhibits at the Mining Exhibition held at Olympia from July 11th to 31st, 1908.

BY

H. H. Hayden.

Mining machinery constituted by far the greater bulk of the exhibits, and included a fairly representative collection of the more readily portable forms of mining plant. There was a marked dearth of prospecting plant, core-drills of every description being entirely unrepresented. Of the mining machinery, a large percentage was devoted to coal-mining, and comprised a limited amount of bulky material, such as boilers and winding-gear, and a larger variety of pumps and mine-fans. These were for the most part of well-known types and call for no special description.

An account of the exhibits of machinery was published in the *Iron and Coal Trades Review* of July 17th, 1908, and is no doubt in the hands of all persons interested in mining in India. I do not propose, therefore, to deal with the exhibits generally, but will confine myself to such appliances as appear to have especial interest in view of the present tendency towards advance in Indian mining methods. These include labour-saving contrivances, such as mechanical coal-cutters, coal-washing and screening plant, conveyors, etc.

MECHANICAL COAL-CUTTERS.

These are principally of three types, *viz.*, disc-cutters, chain-cutters and machines of percussive type. The first two are designed almost entirely for long-wall working and are not, therefore, of general interest to us in India as yet. One chain-cutter, however, the Jeffrey Header, which was exhibited by Messrs. John Davis and Son of Derby, is adapted for pillar and stall workings. The total length of this machine is 10 ft. 3 ins., and the width 3 ft. 2 ins. It is designed for undercutting, and is made to hole either 5, 6 or 7 feet under and 39 or 44 inches wide. It is driven by means of a motor, which can be wound for any voltage up to 500, and either for direct or for alternating current as required. The rated horse-power of the motor is 26. The speed at which the machine is run varies according to the hardness of the material to be cut; with the fast feed a cut of 6 feet under is said to be made in $3\frac{1}{2}$ minutes, with the medium feed the same cut occupies 7 minutes, and with the slow feed, 9 minutes. The cutting-chain carries a number of sockets arranged to hold the cutting-tools alternately horizontal, slanting upwards and slanting downwards. Two men are required to run the machine, which has a weight of 29 cwts.

Coal-cutters of percussive type were represented by a large number of exhibits, which included machines by the Hardy Patent Pick Co. ("Little Hardy" cutter), the International Channelling Machines Co. ("Siskol" cutter), the Diamond Coal-Cutter Co. ("Little Diamond" cutter), and the Ingersoll-Rand Co. ("Radialax" cutter). Machines of this type have been on the market for some years and are well known, but their great labour-saving capacity may not be familiar to all interested in coal-mining in India. Thus in the Mainsforth Colliery (Durham) a

"Siskol" machine is said to have cut ten headings averaging more than 10 feet wide by 5 feet deep—the aggregate cut comprising 516 square feet—in a nine-hour shift. Similarly the *Colliery Guardian* of May 12th, 1905, contained the report of a test run of a "Little Hardy" machine, which sheared twelve rooms, 8 ft. high by 5 ft. to 5 ft. 6 ins. in depth—giving an aggregate cut of 496 square feet—in 8 hours and 25 minutes. Since one of these machines can be run by two men, the increasing value to India of mechanical cutters of this type can be readily appreciated.

All the above percussive cutters are driven by compressed air, but a novel feature has been introduced by the Ingersoll-Rand Co., who propose to combine their "Radialax" cutter with the "pulsator" employed with their "Electric-air" rock drill. The "pulsator" is a small portable motor-driven air-compressor, which is connected to the cutter by two short lengths of flexible hose. Motors are made either for direct or alternating current and both motor and compressor are mounted on a small truck, the weight of the complete unit ranging from 360 lbs. to 883 lbs.

Each of these percussive cutters can be used either for undercutting or for shearing. In the case of the "Siskol" cutter, the change from one direction of motion to the other is accomplished by loosening a single nut and slewing the machine through an angle of 90°, the whole occupation occupying only about a minute.

A SUBSTITUTE FOR EXPLOSIVES IN COAL-MINES.

This is the device known as the "Hydraulic Mining Cartridge," and is made by the Hydraulic Mining Cart-

ridge Co., of Bolton. According to the makers' prospectus, the apparatus " consists of a cylinder of steel, made in various sizes and strengths, but usually 20 ins. long by 3 ins. in diameter, and having eight small duplex rams fixed radially along it. By a suitable arrangement of passages a communication is made between each of these rams, whereby simultaneous action can be obtained..... .... The cartridge is operated by a powerful, though small, hydraulic pump, to which it is connected by a pipe. The pump is of special design, is mounted on an adjustable stand and fitted with a water-tank. The water required for the whole operation is about 1½ pint, but most of this returns to the tank at its completion and can be used again. At the commencement of the operation a small handle is used, and, when pressure has increased, an extension handle is slipped over it and greater power thus exerted. A pressure of three tons per square inch can be reached, and this represents a total pressure on the coal, with the size of cartridge named, of over 60 tons."

The advantages claimed for this apparatus are: absence of the danger consequent on the use of explosives in coal-mines; absence of dust, flame and smoke; a greater percentage of round coal; a better quality of coal (because the coal is not shattered). At the same time it is claimed that the roof is not broken into or injured, whilst there is no loss of the material used, since the same apparatus is used over and over again.

This apparatus would seem to be eminently suited for use on thin coal-seams, but whether it would be effective on such thick seams as are chiefly dealt with in Indian coal-mines, only experience can show.

Both on the score of economy as well as of that of safety it would seem worth a trial.

CONVEYORS AND SCREENING-PLANT.

Amongst the numerous exhibits of mechanical coal-conveyors and screening-plant, the most striking were those of Messrs. Longbotham and Co., of Wakefield, and Head, Wrightson and Co., of Stockton-on-Tees. The former company exhibited a complete working model of a conveying and screening plant recently erected for a British colliery. The plant consists of two through-way revolving tipplers discharging on to two jigging-screens, on which the coal is screened into three sizes, the best coal being delivered direct on to two picking-belts and the cobbles on to a cross tray conveyor, which in turn delivers from both screens on to one picking-belt. The nuts and peas are discharged from each screen on to two vibratory screens, which sort out the peas, the latter falling through a shoot on to a cross tray conveyor, which takes coal of this size direct to the washing-plant, while the nuts are delivered on to a fourth belt. The picking-belts are 58 feet long, and are fitted with lowering jibs 20 feet in length, to minimise breakage of coal after sorting. The plant is worked by a 60 h.p. motor and the lowering jibs by one of 5 h.p.

The conveyor exhibited by Messrs. Head, Wrightson & Co. is known as the "Marcus Propulsion Conveyor" and was an actual outfit ordered for a colliery in Yorkshire. It was designed to deal with 100 tons of coal per hour, classifying it into $\frac{3}{4}$-inch, $1\frac{1}{2}$-in. and 3-inch cubes, the large coal passing over the end of the conveyor. This particular plant consisted of a trough (34 feet long and tapering in width from 5 feet 6 inches to 4 feet) supported on live rollers; the trough is actuated by a driving shaft, having a constant angular velocity, and a propulsion shaft with varying angular velocity. By means of this mechanism, the trough is given a "to-and-fro" motion, which is uniformly

accelerated in the forward stroke and uniformly retarded in the return stroke ; this results in the steady propulsion forward of the material in the trough. In the plant exhibited, the driving shaft made 70 revolutions per minute; the length of stroke of the trough was 10 inches, and rate of forward movement of the material conveyed 70 feet per minute. By means of a series of perforations in the bottom of the trough, this conveyor is employed also for screening, the smallest coal being removed first and progressively larger sizes as the coal moves forward along the conveyor. The screened material is carried away by cross trays placed below the perforated portions. Simultaneously with screening and conveying, hand-picking is carried out by pickers, who stand on either side of the trough.

Amongst the advantages claimed for the "Marcus Conveyor" are reduced wear and tear of machinery owing to the comparatively slow speed of working, and also reduced amount of breakage of coal due to the same cause. The simplicity and ready accessibility of the whole plant seem to render it especially suited to Indian conditions.

COAL-WASHING PLANT.

Coal-washing plant was represented by an exhibit of an Elliot washer by the Hardy Patent Pick Co., and by a number of drawings and photographs exhibited by Messrs. Witting Bros. The latter exhibit represented a rather complicated and costly plant, upon the merits of which it was not possible to form any opinion without either models or description.

The Elliott washer was of the simple trough type, consisting of a wrought iron trough about 3 feet wide at the top, 2 feet 6 inches at the bottom, and about 10 inches in depth. At each end of the trough are two sprocket

wheels, one at either side, over which run two endless chains. Attached to the chains are scrapers, about $2\frac{1}{2}$ inches deep, and made to fit the lower section of the trough; they thus constitute movable stops or dams, which, by means of the chain, are slowly drawn along the bottom of the trough against the stream of water flowing down it. The trough being fixed at a suitable inclination, water is admitted at the higher end and the coal at about the middle of its length. As the water runs down, it carries with it the coal, whilst the dirt, having a higher specific gravity, sinks to the bottom of the trough and is conveyed by the scrapers to the upper end where it is ejected.

COKE-OVENS AND BYE-PRODUCT PLANTS.

The only coke-oven exhibited was that of the Koppers Coke-oven and Bye-Product Co. of Sheffield, who showed sectional parts of their regenerator oven, built with their specially designed fire-bricks, and illustrating the construction at the top and the base of the oven. They also exhibited models of their waste-heat and regenerator ovens and drawings of their bye-product plant.

The chief feature of the Koppers' oven is the method of heating, which depends on the introduction of a large number of vertical flues—30 to 35—on either side, each of which is provided with a heating jet and also with means of regulating the supply of gas and air. The result of this is claimed to be perfect uniformity of heating throughout the whole length of the oven.

As the Koppers' oven and bye-product plant has only been on the market for a few years and has only quite recently come into notice in Great Britain, the following short description, based on particulars furnished by the makers, will probably be of interest:—

The Waste-heat Oven.—Plate IV, figs. 1-6, shows longitudinal and cross-sections through the oven chamber and heating flues. Figure 1 is a longitudinal section through one of the walls and shows the arrangement of the heating flues; fig. 5 is a longitudinal section through the oven chamber; whilst fig. 6 shows three different cross-sections through a series of ovens.

The oven chamber is 10 metres long, 2 metres high and from 0·5 to 0·6 metre wide at the centre. The height and width, however, vary somewhat according to the class of coal to be coked. The top of the oven is provided with three openings, A, for charging the coal, and a fourth, B, through which the gases of distillation are drawn off to the condensing plant. The purified gas is returned from the bye-product plant by the main, C, placed in a position convenient for access, either in front of or at the back of the battery of ovens. Separate branch supply pipes, D, fitted each with a regulating cock, conduct the gas to each oven, and these branch pipes communicate with the gas-distributing channel, E (fig. 3.), placed immediately below the heating flues. E is built of fire-brick pipes and runs along below all the heating flues except one or two at the end remote from that at which the gas is admitted; these latter conduct the waste heat to the main flue, P, leading to the boiler plant. The heating gas passes out of the distributing channel through orifices, each of which is fitted with a gas nozzle communicating with a vertical flue.

The air for combustion flows along the conduit, F, and, induced by the chimney draught, is drawn into the air-distributing channels, G, situated immediately beneath the oven chambers. The air enters each heating flue through the openings, H, and meets the gas issuing from the gas-nozzles, U. Combustion takes place just above the nozzle

and the products of combustion of the gas and air pass up the heating flues, K, and through the openings, L, at the top of each flue. These openings are provided with a damper, M, which can be regulated so as to admit the exact amount of air necessary to ensure perfect combustion. The sliding bricks (dampers) are accessible from the top of the ovens through the openings, N, which are fitted with removable plugs (fig. 2). These openings at the top of the ovens serve both to provide means of regulating the dampers and also to give access to the gas-nozzles, U ; they further permit of the flues being inspected at any time. The gas-nozzles are provided with oval orifices, and can be removed by means of a special rod (fig. 4).

After passing through the openings at the top of the heating flues, the gases of combustion flow along the horizontal flue, O, in the direction indicated by the arrows (fig. 1) and finally pass down into the main flue, P, leading to the boiler plant. The outlet flue from each oven is provided with a regulating damper, R, by means of which the chimney draught is adjusted.

Since each oven wall contains a large number of vertical flues, each of which is provided with a separate heating jet capable of regulation, it is claimed that the heating of the oven can be so controlled as to render it possible to keep the temperature uniform throughout the whole length of the oven : this is said to result in the production of a homogeneous coke and at the same time in a reduction of the length of time required for the operation and consequently in an increased yield of coke.

The coke is removed from the oven by means of a mechanical ram.

The Regenerator Oven.—This is designed on identical lines to the waste-heat oven from which it differs only in

that the air for combustion is previously heated by means of regenerator chambers. Figures 7, 9 and 10 show longitudinal and cross-sections through the regenerator oven. The air for combustion flows along the passage-ways, A, at the front and back of the ovens, and passes thence into the regenerators through the inlets, B. The air is heated in the regenerators to a temperature of 1,000° C., and then passes into the vertical heating-flues through the openings, C. The purified gas from the bye-product plant is returned to the ovens by the mains, D, which run the whole length of the ovens on either side. Branch supply pipes, H, carry the gas into the distributing channels, E, which are placed directly beneath the oven walls; thence it passes through the nozzles, F, into each vertical flue, where it ignites with the hot air entering through the passages, C (fig. 8). Thus a jet is formed on a level with the oven floor in each of the heating flues of the oven chamber.

Bye-Product Plant.—The figure (Plate V) shows the general arrangement of the bye-product plant. The hot gas from the coke-ovens enters the preliminary cooler, A, which is of the multitubular type, and, after passing through the tubes, is led into the water-coolers, B, where the temperature is reduced to about 25° C. The gas is then drawn off by means of an exhauster, C, and passed into the tar-extractor, D. After having been freed from the tar, it then returns to the preliminary cooler, A, where it passes up between the tubes, being thus warmed up itself and at the same time serving to cool the hot gas coming from the ovens. It is next led along the main, F, to the acid saturator, E, in which the ammonia in it is extracted by direct contact with sulphuric acid and is recovered in the form of sulphate. The saturator is of the totally enclosed type and the sulphate is removed from it by means of an injector.

This salt is then delivered on to a collecting table, whence it is run off, together with the accompanying mother-liquor, into a centrifugal dryer, L.

The products of condensation which are extracted in the cooling and tar-eliminating operations, are drawn off from the several apparatus and delivered into a separating tank, H, where the tar and ammoniacal liquor separate according to their specific gravities. The tar flows into the storage tank, I, and the gas liquor into the storage tank, J; this liquor is then pumped into the ammonia still, G, where the ammonia is driven off by means of steam and lime. From the still, the vapours of distillation pass into the main, F, where they mix with the heated gas which is passing to the saturator.

It is claimed that by this method the tar is completely removed from the gas before it enters the saturator, and that the ammonium sulphate is accordingly quite free from any admixture of it.

DISINTEGRATORS.

The machinery, other than that especially pertaining to coal-mining, included a large number of rock-breakers and disintegrators of various types. These consisted chiefly of ring-disintegrators, jaw-crushers, rollers, and ball-mills; these were of well-known types and call for no special mention, but it was interesting to note the extensive use to which manganese steel is now put in the manufacture of the working parts of these machines. The Hadfield Steel Co., of Sheffield, exhibited a large number of articles of this nature, made of their "Era" manganese-steel.

In addition to the above disintegrators, there was an exhibit by Messrs. Holman Bros. (Camborne) of their pneumatic ore-stamper, which, although not a novelty,

—having been on the market for some years—has not yet, apparently, received the attention it would seem to deserve. It is said to be both cheaper and more economical than the Californian stamp, whilst the makers claim that one head of their pneumatic stamp is capable of doing the work of nearly twelve heads of the Californian type. Figures furnished by them show that during a trial made at the Dolcoath mine, one pneumatic stamp, having a weight of 1,250 lbs., and working at a speed of 138 blows per minute, crushed 20 tons and 1 cwt. of ore at a cost of 16·311 pence per ton, whilst a Californian stamp, weighing 950 lbs., and working at a speed of 90 blows per minute, crushed only 1 ton and 12 cwts. at a cost of 20·203 pence per ton; and whereas the former stamp crushed $533\frac{1}{6}$ tons in a continuous run of 635 hours, the latter crushed only $42\frac{1}{4}$ tons.

BRIQUETTING-PLANT.

Although coal-briquetting machinery was entirely unrepresented in the exhibition, there was an interesting exhibit of the results of the concentration and briquetting of iron ore by the Grondal Kjellin Co. of Stockholm. The concentrating process is designed with a view to treating magnetic ores of low grade. The ore is first reduced in jaw and vertical crushers until it will pass through a 2-inch screen. It is then wet-ground in a ball-mill to a fine pulp, which is passed wet through a magnetic separator consisting of a revolving drum enclosing a specially designed magnet. The pulp passes below the drum, which attracts the magnetite and carries it round to the limit of the magnetic field, where it is carried away by a spray of water. The concentrate thus obtained flows to settling-boxes, in which it is dried until the moisture is reduced to about 8 per cent. It is then conveyed to a press, in which, by

means of two blows from a falling hammer, it is pressed into briquettes sufficiently firm to permit of handling. As these issue from the press, they are loaded on to a truck, which is then run, with its load of briquettes, into a furnace consisting of three chambers, first a heating chamber warmed by the waste gas coming from the second or combustion chamber. This second chamber is a gas furnace, in which the briquettes are heated to between 1,300° and 1,400°C., at which temperature the material of the briquette sinters sufficiently to form a hard block, which will stand rough handling. From the combustion chamber, the briquettes, still on the trucks, pass through a cooling chamber in which their temperature is said to be reduced sufficiently to permit of their being handled when they reach the discharging doors. From the time the trucks, with their loads of briquettes, enter the first, or heating, chamber, they are kept steadily moving at a slow rate until they emerge at the discharing doors, the progress from one end of the furnace to the other occupying 24 hours.

Amongst the advantages claimed for this process are the conversion of a magnetic into a hematitic ore (by oxidation after the briquettes pass from the combustion chamber into the cooling chamber) and the production of a fine lumpy ore, hard enough to stand rough treatment and long transport, but yet sufficiently porous to admit of easy reduction in the blast furnace.

This briquetting process is also adapted to the treatment of ores containing a high percentage of sulphur, which constituent is burnt off in the furnace.

The fuel employed in the furnace is gas, and it is stated that in briquetting iron-ore concentrates, and using producer gas, the consumption of coal in the producer plant

has been found to average 7 per cent. of the weight of briquettes burnt.

SCIENTIFIC INSTRUMENTS.

There were two exhibits of scientific instruments, one by Messrs. John Davis and Son of Derby, and the other by the Cambridge Scientific Instrument Co. The former exhibit comprised theodolites, tacheometers, clinometers, and other surveying instruments, together with a new form of mine-anemometer with registering apparatus constructed on the principle of the stop-watch and suitable for use by unskilled workmen.

The exhibit of the Cambridge Scientific Instrument Co., although small, was one of considerable interest, since it comprised the most recent forms of thermo-electric thermometers and radiation pyrometers, both types being shown in actual work. The thermometer consists of a porcelain tube in which is enclosed a thermo-electric couple composed of two fine wires of different metals or alloys fused together at one end, the free ends being connected to the terminals of a delicate galvanometer (millivoltmeter) on which are scales reading in both millivolts and degrees centigrade.

The couples employed are copper-constantan for temperatures up to 500°C., platinum-platinum with 10 per cent. iridium for temperatures up to 1400°C., and platinum-platinum with 10 per cent. rhodium for temperatures up to 1600°C. The galvanometer is made in two forms, one for direct reading and the other also for automatic recording.

The radiation pyrometers exhibited were of the Féry type, consisting of a concave mirror, in the focus of which is fixed a thermo-electric couple the free ends of which are

attached to a millivoltmeter. By means of a telescopic arrangement, the instrument is focussed on the object of which the temperature is to be determined, and the temperature read off the millivoltmeter scale, which is arranged to read either from 600° to 1800° C., or from 1000° to 2000° C. The advantage of the radiation pyrometer lies of course in the fact that it is not in contact with, but may be set up at some distance away from, the source of heat; it is therefore suitable for measuring temperatures much higher than those which can at present be conveniently determined by means of instruments which must be in contact with the source of heat. I understand that a new and improved form of this pyrometer is being brought out by the Cambridge Scientific Instrument Co., but it was not exhibited.

MINERALS AND METALS.

Although the greater part of the exhibits consisted of machinery, there were also a few collections of raw products and metals. These exhibits were, however, comparatively insignificant, the largest being those of Western Australia and of New South Wales. The former collection was particularly well arranged and comprised commercial samples of the chief mineral products of the Colony. An interesting sample was a pan of monazite, which is said to be obtainable in large quantities near the Pilbara Goldfield.

There were also a miscellaneous collection of minerals, chiefly in the form of museum specimens—from Rhodessia an exhibit, by Messrs. Hopkin and Williams, of ore, and salts of uranium and thorium; another of nickel, nickel-salts and copper sulphate produced from the Victoria (Ontario) ore by the Mond Nickel Co.; and a small exhibit

by the British Mining and Metal Co., of Cornish minerals and ores, with their derived metals and salts.

An interesting exhibit, by the Kent Coal Concessions Co., consisted of cores of gault, sandstone, coal and fire-clay obtained from borings put down to test the coal-measures underlying the Cretaceous beds in the area between Canterbury and Dover.

None of these exhibits call for special notice and are merely mentioned in order to show the comparative insignificance of exhibits other than those of machinery.

ABSTRACTS AND NOTICES.

SKETCH OF THE MINERAL RESOURCES OF INDIA.

By T. H. Holland, D.Sc., F.R.S., Director of the Geological Survey of India. Published by order of the Government of India. Calcutta, Geological Survey Office. Price Re. 1-2, pp. 86 and xi and three maps.

An admirable summary of the mineral resources of India is condensed within these 86 pages by the Director of the Geological Survey who now, it is pleasing to note, can be addressed as Sir Thomas Holland, K.C.I.E. After a brief sketch of the Indian geology the author makes a gratifying forecast of the mining and metallurgical industries of the country which are now so markedly on the up-grade. In 1902 the total value of minerals, for which regular returns of production were available, was £4,549,630. In 1906 the amount had risen to £6,312,818, and the year 1907 has shown a still more noteable advance to £7,071,868 as shown by the same author in the statistics published in the Records of the Geological Survey, Vol. XXXVII, Part 1. The products, which have given this result, are described in the following order:—

(1) Carbon and its compounds, including amber, coal, graphite and petroleum.

(2) Metalliferous minerals and metals, including ores of aluminium, antimony, arsenic, chromium, cobalt, copper, gold, iron, lead, manganese, molybdenum, tantalum, tin, tungsten, uranium and zinc.

(3) Minerals used in various industries, such as alum, asbestos borax, building materials, copperas and blue vitriol, corundum, fluor spar, gypsum, magnesite, mica, mineral paints, mineral waters, phosphates, potash salts, salt, other soda salts, steatite and sulphur.

(4) Gem-stones, including agate and the various forms of silica, beryl, chrysoberyl, diamond, garnet, jadeite, ruby and sapphire, spinel, tourmaline and zircon.

FENCE GATES FOR PIT CAGES.

Mr. W. H. Pickering * has raised the question of the advisability of using fence gates for pit cages. Statistics of 483 fatal shaft accidents in the United Kingdom for the years 1902—1907 inclusive show that 129 deaths were caused while ascending or descending. The risk, though perhaps small when it is considered that half a million men are raised and lowered in cages daily, is still capable of reduction. It is advisable that as many men as possible should ride in the cage at once for the sake of speed in operation and the reduction of the number of windings. For this effective cage gates are thought to be necessary. Mr. Pickering submits that an ideal gate should (1) be automatic, (2) be simple in action and construction, (3) be of use when coal is being drawn, (4) have no projections into the shaft, (5) be incapable of opening outwards into the shaft, and (6) be able to stand the impact of a collision. He is aware that it is quite impossible to devise a gate to suit all cages. In some cases a simple arrangement of fencing worked by hand will be sufficient; in others, more elaborate automatic gates are desirable. The gates should be made to fit the conditions, and not the conditions to fit the gates.

To summarise, Mr. Pickering is of opinion that cage gates should be provided for the following reasons :—

(1) To meet different conditions of work into which we are passing.
(2) To prevent persons falling from cages from illness, panic, collisions or hurry.
(3) To prevent disorder and confusion.
(4) To enable more persons to be raised safely each journey.
(5) To prevent damage to the shaft and shaft-fittings by tubs falling from the cages.

The appendix attached to the paper contains brief descriptions of several fence-gates.

MANGANITE.

In a paper read before the Manchester Geological and Mining Society on June 16th, 1908, Mr. A. Ghose describes the mode of occur-

* Transactions of the Institution of Mining Engineers, 1908, Vol. XXXV, p. 271.

rence of manganite in the manganese on deposits of the Sandur State, Bellary, Madras.

Of the various hypotheses propounded from time to time to account for the origin of the manganese ore-deposits of the Sandur State, two theories appear to be based on comparatively sound deductions. One of these advocates a contemporaneous sedimentary origin, and the other maintains that the deposits are essentially the result of replacement of the original country rock by mineralizing solutions.

STEAM CONSUMPTION OF A TWIN TANDEM WINDING ENGINE.

The twin tandem winding engine at the Werne Colliery of the Georgs-Marien-Bergwerksund Huttenverein, of Werne, Westphalia, is of the horizontal type, with high-pressure cylinders 32 inches in diameter, and 50 in. low-pressure cylinders and a 64 in. stroke. It is fitted with a condenser, and was constructed to raise a net load of 5½ tons from a depth of 3,300 ft., by means of a 26 ft. Koepe pulley, at a mean velocity of 48 ft. per second. The high pressure cylinders are mounted on slides, to allow for expansion, and the valve gear is so arranged that, in starting the engine, full admission is given, whilst on pushing the lever further, the cut-off is adjusted to give an expansion up to 30 per cent. Moreover, to facilitate starting, live steam can be admitted to the heated receiver. Steam, at a working pressure up to 14 atmospheres, is supplied by three Babcock and Wilcox boilers with a total heating surface of over 11,800 square feet, so that any considerable fluctuation of the water-level in starting the engine is precluded.

In a series of tests recently made with this engine, the steam pressure in the boiler was 12·6 to 12·9 atmospheres, and 12·3 to 12·5 atmospheres at the engine, the temperature being 199·5 to 200 degs. Cent. The total consumption of water in five hours amounted to 570,195 lb., and the steam consumption to 569,205 lb.; 99 lb. of condensed water were drained from the pipes. The time occupied in each wind averaged fifty-five seconds, or 114·6 seconds, including loading and unloading the cages. Out of this period, steam was being admitted to the cylinders during twenty-eight seconds, the engine making 18 revolutions in that time. The mean rope velocity was 44 ft. per second; 156 winds were made during the test, and 806 tons of net load were raised from a depth of 2,423 ft. The effective energy was 440·91

horse-power per hour, and the steam consumption 11·385 lb. per hour, equivalent to 25·80 lb. per horse-power hour.

The steam consumption is considerably lower than hitherto considered practicable, and even in view of the losses sustained owing to the long pauses during the night shift, the results are very favourable, for, allowing a loss of 15 per cent. for that shift, the mean steam consumption works out at 18¾ lb. per horse-power hour, taken over the whole twenty-four hours. In addition to the excellent design of the engine, the special banking arrangements at the pit contributed largely to the favourable result obtained.—*Gluckauf* through the *Colliery Guardian*, March 29th, 1907, p. 588.

WORKING COAL BY THE FLUSHING SYSTEM.

Mr L. W. Mayer* describes some of the methods of coal mining in Silesia where the workings are filled with materials flushed down from the surface by water. Attempts have even been made to employ air as the carrier, but the experiments, though still in progress, do not appear to offer a very favourable outlook. Material the size of a nut and downwards could be carried through pipes by air and dropped in the workings but the mine air was rendered very dusty.

In the ordinary pillar and stall working, as in the 22 foot seam of the Deutschland colliery near Kattowitz, Upper Silesia, pillars 42 by 72 feet are blocked out by roads 6 feet in width. They are then worked back in steps on a line approximately at 45° to the roads and the roof allowed to fall in. The surface is very considerably disturbed by subsidence.

The flushing system is used at the Myslowitz colliery which raises 2,600 tons daily from levels at 780 and 1,100 feet in depth. The seam is 28 to 37 feet in thickness. Sand is used as filling and is quarried from a bank 20 feet high and 1,500 feet long, half a mile from the colliery. It is quarried and loaded by a bucket dredge, driven by a 30 H.P. electromotor, into wagons which convey about 3,000 tons in 24 hours. The sand is unloaded through a grating into a hopper whence it is washed by water from an electrically driven pump into one of two boreholes. It seems difficult to obtain consistent opinions relative to the amount of water required as compared to the volume of sand. It is claimed at

* *Engineering and Mining Journal*, Vol. XXXVI. pp. 887—892.

Myslowitz that the proportion is 1 to 1, whereas at other quarters this is questioned, it being claimed that the proportion is nearer 2 to 1. The figure in general depends, to an extent, on the horizontal distances through which the filling material has to pass underground, the head, the artificial pressure which may be supplied at the mouth, and the characteristics of the material being flushed.

It is calculated that 1 foot of vertical fall affords transport of material over 10 feet horizontal, and 1 atmosphere of pressure is equal to 1 m. of vertical fall, so that an application of eight to ten atmospheres would mean eighty to one hundred metres transport in addition to the pressure head.

As before mentioned, the thickness of coal taken may be as much as 40 feet, and the method in this instance would be to remove same in slices of 20 feet each. The first slice may be taken at 23 feet. The work consists in first blocking out the lower slice, by means of headings 6½ by 6½ feet into squares 32 to 40 feet in width, and 40 to 45 feet in length, the long dimension of the pillars being in the direction of the dip, which attains 12 degrees. The hard formation overlying the seam, and the dip abovementioned, in conjunction with a desirable material for filling, makes this an ideal flushing proposition.

Cost of Pipes used in Flushing.

Sand is conducted to the rooms in pipes of Mannesman Steel, which are 7 in. diameter. The steel is 0·31 in. thick, and the pipes are in 20 feet lengths. There is at present in the mine approximately 24,000 ft. of pipe.

Various materials have been used, but the steel above mentioned has met with the greatest favour. The cost of pipe is given at about three shillings per foot in France. Along the line of the pipe in the mine, turns are made by means of elbows, which usually have a radius of about 4 to 5 feet. The elbows are usually made of cast iron, and wear out rapidly. A piece of sheet iron is held against the worn-out portion of the elbow by means of iron straps equipped with nuts and bolts. These branches are controlled by means of gate valves, which, at Myslowitz, are of the plunger type. The tendency is to abandon gate valves, and regulate the inflow by branching off, re-directing the flow when one place is filled.

Joints are made by means of bolts, which pass through six to

eight holes in loose rings surrounding the flanged ends of the pipes. In making connections from the vertical line to the horizontal, it is found advisable to have an angle of at least 130 deg. between an imaginary line connecting the vertical and horizontal directions and the lines of directions themselves.

The lower six or seven yards of the thick seam being blocked out in an area, the pillars are attacked, much in the same way as at the Deutschland mine, where, however, the withdrawal of the timbers is not done in conjunction with filling, but is accompanied by roof falls.

In setting the timbers, plugs are first driven into the roof, and the caps are hung from these plugs with wire, or light rope. Posts are now brought into the room and set under the caps in regular order.

At the upper end of the pillars, legs of protection are left. These legs are finally mined with the main pillar of the next tier above, but not before the sand in the chamber outside it is entirely filled and drained. Before running the flushed sand into the chamber, dams are placed to confine the sand. These dams are formed of posts and 2 in. planks, which latter are nailed to the posts and are made tight by means of some packing material, such as straw.

Distribution of the Filling.

As the mass of filling rises behind the dam, the centre boards are set. The chamber being filled, mining is started in the next room, and while there is more or less coal left standing, in approaching the adjacent filled chamber, it is surprising to see how firmly this sand sets after being allowed to thoroughly drain. The coal shell standing is finally scaled off by the miners in the course of the work, until the filling begins to break in from above, which does not generally occur until practically all the coal has been gotten. The filling pipe usually being brought through an opening in the legs. In flushing, the pipe is usually brought to about the centre of the chamber, and when the area has been filled up to this point, the pipe is brought back until finally it is set close up to the roof at the head of the chamber.

The sand finds its way into the crevices of the coal in the adjacent pillars, and tends to strengthen them. It requires about three or four days for the water to drain off, and the sand then sets in a concrete-like manner. At many points in the mine, a cane could be pushed into the sand by hand for a few inches only.

Removal of a pillar requires about two shifts of six men; it also requires about sixteen hours to fill such a chamber with sand. It is said that 1 cu. ft. of sand is filled for every 1·35 cu. ft. of coal mined.

The work in the upper slice is carried on quite similarly to that in the lower slice. There is a certain settlement inevitable in the sand, which, it is claimed, amounts to five or six per cent. of the height of the area filled. In virtue of this settlement, a certain bending of the upper coal ensues, and it has been found that on account of this, the coal in the upper slice breaks easier than that in the lower.

The floor on which the men work in the upper slice is the sand filling of the lower slice. The track equipment is laid out in the ordinary manner. While this floor is quite hard, the pack is subject to more or less disintegration. In order to avoid a mixture of coal and sand, iron plates are laid on the floor, on to which the coal from the face is dropped.

The water, in draining off from the sand, has more or less solid matter in it, and is quite muddy in appearance. In order to clear this water of the suspended material, drifts are set apart in the lower part of the mine, and are dammed off with concrete masonry. The walls of these concrete dams are countersunk into the floor and hitched into the roof. The drifts may be set off several hundred feet long.

To permit the clarified water to pass the dam, short lengths of 3 in. pipe are set in this wall in a line, one above the other, about 2 ft. apart. The outer ends of these pipe lengths are fitted with stop-cocks. Then the elevation from which water shall be permitted to flow off is regulated according to whether this water is clear or not.

The muddy water coming into the reservoir is allowed to rest, and the suspended material settles at the bottom. The clear water is drawn off by means of these pipes, and passes on to the mine sump. When one of these chambers has been entirely filled with mud, another one is selected, and similarly fitted with a dam.

Flushing at other Mines in Silesia.

Information was obtained relative to operations at various other mines where flushing with water was being carried on, though these mines were not visited. At the Heinitz mine, near Benthen, cinders, clay, broken bricks, and all kinds of refuse are flushed down a vertical hole 1377 feet deep; the pipe is 7·16 inches in diameter.

Before passing into the hole, all the material first goes through a grate having 3½ inch apertures. This material is swept to the hole from a waste heap by means of hydraulic giants which pass a stream under 30 atmospheres pressure; this pressure is developed by a centrifugal pump.

At the Ferdinand mine, near Kattowitz, where the coal is 2½ ft. thick, and dips 25 per cent., city waste is contracted for, for filling purposes. This material is brought to the shaft by 8 h.p. benzine locomotives, which draw dump cars of 35 cubic feet capacity. Sufficient clay and sand are added to make the conglomerate bind.

The water supply is pumped from an adjacent stream. The dump cars discharge their load into a large hopper-shaped bin the top of which is equipped with a grating. From this bin the material passes on to a funnel-shaped receptacle, which is connected directly to the main pipe line leading down the shaft; this shaft is 185 ft. in depth. These are two pipe lines, one, a reserve pipe, supported in the shaft at intervals by means of I-beams. Underneath the screen, which is placed in the funnel-shaped receptacle, there is a rising current of water: this screen has 4 inch holes.

Underground, a wooden nozzle spout is at the end of the pipe line, which permits of readily changing the direction of the inflowing current about the chamber. It is claimed that the cost of filling is about 6½ annas per ton. At Myslowitz the cost is said to be somewhat lower than this, figuring closely to 5 annas per ton.

Flushing at the Trinity Colliery.

At the Trinity colliery in Austrian Silesia, a mixture of sand, clay, waste and mine rock is effected. The rock is brought to the surface filling plant and crushed. The sand is brought to a separate bin, the dumping being effected with an ordinary cylindrical type of dumper. These hopper units are 13 ft. apart. The two materials are now led to the main hopper, which connects with the pipe line. This is 720 feet long; the pipes are 5·7 in. in diameter, and 0·26 in. in thickness. This main hopper is about 30 in. in diameter at its upper end. At a distance of 18 in. below the hopper top is a screen, which has square holes of 2·4 in. dimensions. Thirty-five per cent. of the mixture is clay, the other sixty-five per cent. being sand and broken rock.

In order to facilitate the flushing of this material, there are three

2 in. branch pipe lines, which emanate from a main conduit of 5½ in. One branch points directly downwards on to the grating in the funnel, and the other two branches pass below the funnel, enter it from below, and afford a rising current against the bottom of the screen.

At the Tielfan colliery in Moravia (Austrian Silesia), until recently, granulated slag only was conducted into the mine workings. The plant is so arranged that the slag comes either from the smaller works and passes directly down the shaft pipe line, or else passes into a storage bin. This bin, or reservoir, serves in case of stoppages at the smaller works. Recently binding material in the shape of culm from the coal washery has been intermixed with the slag. The culm and slag are led to the main pipe line by separate hoppers.

At the Deutscher Kaiser Colliery, Westphalia, the coal is 5 ft. thick, and dips at 33 per cent. Slag and sand is the filling material there also. An innovation is the use of canvas brattices instead of solid wooden dams, to hold back the filling in the chambers underground Joists of timber are placed about 4 to 6 in. apart, against the upright posts, and canvas is stretched over the joists. It has been found that by this method the water which filters through the canvas is clean enough to pass on to the pumps without further settlement. Canvas brattices are also used at Lens, Pas de Calais, France.

OF INDI

H. H. HAYDEN.

Transactions Vol. III. Plate IV.

KOPPERS' WASTE HEAT COKE-OVEN.

Scale 10 Feet to 1 Inch.

Fig 1.-Longitudinal Section through Heating Flues.

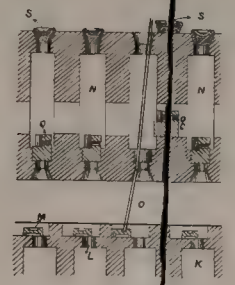


Fig 2.-Longitudinal Section through Heating Flues

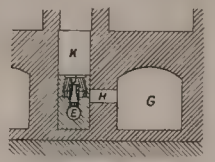


Fig 3. Cross Section through Gas nozzle

Fig 4 Cross Section through Gas nozzle.

Scale 2½ to 1 Inch

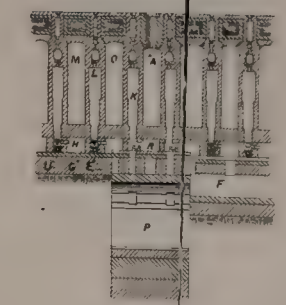


Fig 6.-Three Cross Sections through Ovens

Scale 10 Feet to 1 Inch

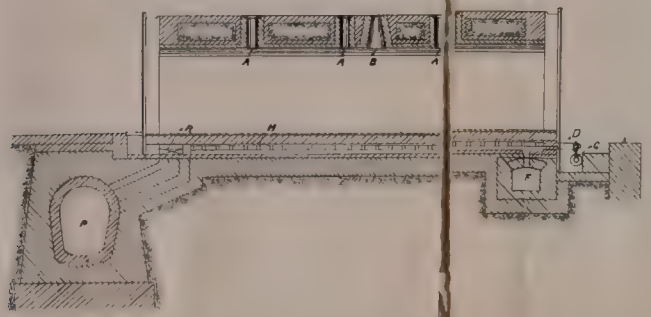


Fig. 5 Longitudinal Section through the Oven chamber.

Scale 10 Feet to 1 Inch

KOPPERS' REGENERATOR COKE-OVEN.

(Separate Regenerators for each Oven)

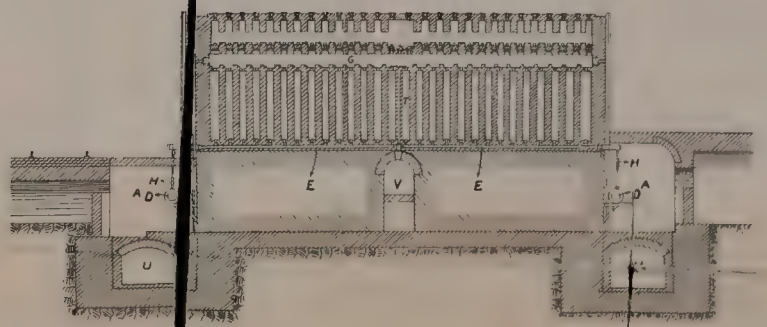


Fig. 7.-Longitudinal Section through Heating Flues.

Scale 10 Feet to 1 Inch

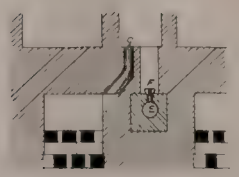


Fig 8-Cross Section through Gas-nozzle.

Scale 2½ to 1 Inch

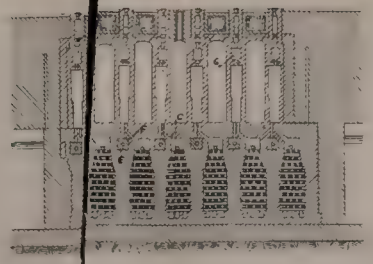


Fig 10.-Cross Section through Ovens.

Scale 10 Feet to 1 Inch

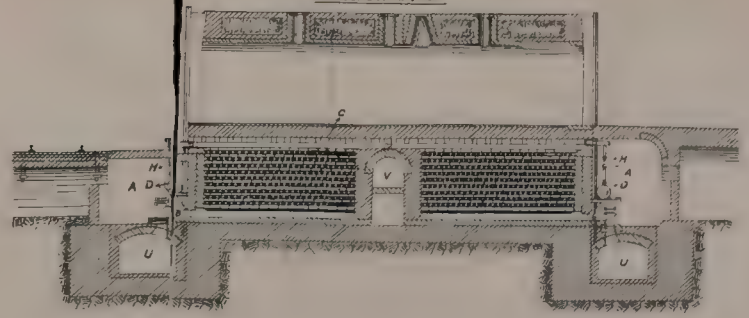
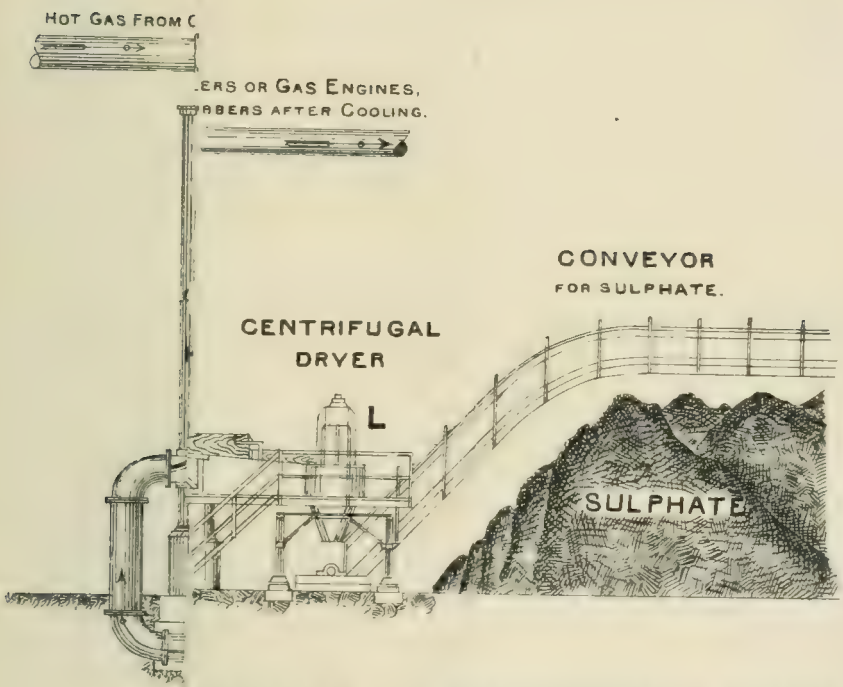


Fig 9.-Longitudinal Section through the Oven-chamber

Scale 10 Feet to 1 Inch

H. H.

Transactions, Vol. III. Plate V.



SYSTEM OF BYE-PRODUCT PLANT

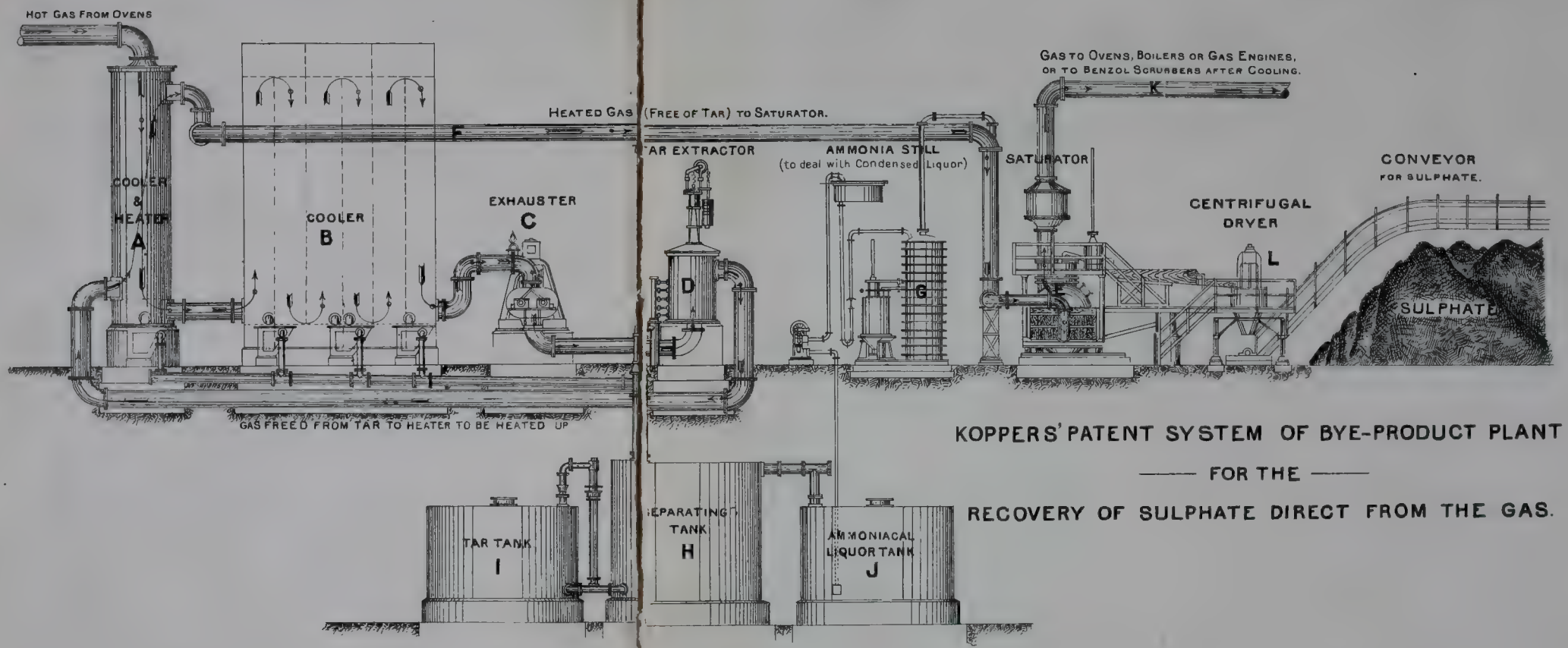
— FOR THE —

ULPHATE DIRECT FROM THE GAS.

MINING AND GEOLOGICAL INSTITUTE OF INDIA.

H. H. HAYDEN.

Transactions, Vol. III. Plate V.


HOT GAS FROM OVENS
COOLER & HEATER A
COOLER B
EXHAUSTER C
HEATED GAS (FREE OF TAR) TO SATURATOR.
F
GAS FREED FROM TAR TO HEATER TO BE HEATED UP
TAR EXTRACTOR D
AMMONIA STILL (to deal with Condensed Liquor) G
GAS TO OVENS, BOILERS OR GAS ENGINES, OR TO BENZOL SCRUBBERS AFTER COOLING.
K
SATURATOR E
CENTRIFUGAL DRYER L
CONVEYOR FOR SULPHATE.
SULPHATE
TAR TANK I
SEPARATING TANK H
AMMONIACAL LIQUOR TANK J

KOPPERS' PATENT SYSTEM OF BYE-PRODUCT PLANT

—— FOR THE ——

RECOVERY OF SULPHATE DIRECT FROM THE GAS.

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